# Remedial Action Contract for Remedial Response, Enforcement Oversight, and Non-Time Critical Removal Activities at Sites of Release or Threatened Release of Hazardous Substances in EPA Region VIII

U.S. EPA Contract No. EP-W-05-049

## Draft Report

# Remedial Investigation Report
# Operable Unit 4 - Residential and Commercial Properties
# Libby Asbestos Superfund Site
# Libby, Montana

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|---|---|
| Work Assignment No.: | 229-RICO-08BC<br>Libby Asbestos Superfund Project, OU4 and OU7 Remedial Investigation/Feasibility Study |
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# Acronyms

| | |
|---|---|
| % | percent |
| $<$ | less than |
| $\geq$ | greater than or equal to |
| °F | degrees Fahrenheit |
| µm | micron |
| ABS | activity-based sampling |
| ACM | asbestos-containing material |
| AHERA | Asbestos Hazard and Emergency Response Act |
| AIHA | American Industrial Hygiene Association |
| ASTM | American Society of Testing and Materials |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BCY | bank cubic yard |
| bgs | below ground surface |
| BNSF | Burlington Northern and Santa Fe Railroad |
| CARB | California Air Resource Board |
| $cc^{-1}$ | per cubic centimeter |
| CDM | CDM Federal Programs Corporation |
| CE | Cleanup Evaluation |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| COC | chain-of-custody |
| $cm^{-2}$ | per square centimeter |
| $cm^2$ | square centimeters |
| CSF | close support facility |
| CSS | Contaminant Screening Study |
| CVCC | Cabinet View Country Club |
| DQO | data quality objective |
| EDD | electronic data deliverable |
| EIC | Exterior Inspection Checklist |
| eLASTIC | electronic Libby Asbestos Sample Tracking Information Center |
| EPA | United States Environmental Protection Agency |
| ERS | Environmental Resource Specialist |
| f/cc | fibers per cubic centimeter |
| $ft^2$ | square feet |
| FTL | field team leader |
| FS | feasibility study |
| FSDS | field sample data sheet |
| Grace | W.R. Grace and Company |
| HEPA | High Efficiency Particulate Air |
| IDW | investigation-derived waste |
| IEC | International Electrotechnical Commission |
| IFF | Information Field Form |
| ISO | International Organization for Standardization |

| | |
|---|---|
| KDC | Kootenai Development Corporation |
| L | liter |
| L/min | liters per minute |
| LA | Libby amphibole asbestos |
| LCEH | Lincoln County Environmental Health Department |
| Libby Site | Libby Asbestos Superfund Site |
| MCE | mixed cellulose ester |
| $mi^2$ | square mile |
| mm | millimeter |
| NIOSH | National Institute of Occupational Safety and Health |
| NIST | National Institute of Standards and Technology |
| NPL | National Priority List |
| NSUA | non-specific use area |
| NVLAP | National Voluntary Laboratory Accreditation Program |
| ORD | Office of Research and Development |
| OSHA | Occupational Safety and Health Administration |
| OU | operable unit |
| PARCC | precision, accuracy, representativeness, completeness, and comparability |
| PAT | Proficiency Analytical Testing |
| PCB | polychlorinated biphenyl |
| PCC | Property Closeout Checklist |
| PCM | phase contrast microscopy |
| PDI | pre-design inspection |
| PE | performance evaluation |
| PLM | polarized light microscopy |
| PLM-VE | polarized light microscopy-visual estimation |
| PPE | personal protective equipment |
| QA | quality assurance |
| QAM | quality assurance manager |
| QC | quality control |
| RAFS | releasable asbestos field sampler |
| RAM | real-time aerosol monitor |
| RI | remedial investigation |
| RSQ | remediation status query |
| $s/cm^2$ | structures per square centimeter |
| s/cc | structures per cubic centimeter |
| SAP | sampling and analysis plan |
| SEIC | Supplemental Exterior Inspection Checklist |
| SEM | scanning electron microscopy |
| SIIC | Supplemental Interior Inspection Checklist |
| SOP | standard operating procedure |
| SQAPP | Supplemental Remedial Investigation Quality Assurance Project Plan |
| SRC | Syracuse Research Corporation |
| SSVR | small scale vermiculite removal |
| SUA | specific use area |
| TEM | transmission electron microscopy |
| USGS | United States Geological Survey |

| | |
|---|---|
| VCBM | vermiculite-containing building materials |
| VCS | vermiculite-containing soil |
| VOC | volatile organic compound |
| VVEF | Visual Vermiculite Estimation Form |
| XRD | x-ray diffraction |
| $yd^3$ | cubic yard |

also Meeker

# Section 1 Introduction

The purpose of this remedial investigation (RI) report is to present sufficient information to support a feasibility study (FS) and remedial action decisions for the residential, commercial, industrial, and public properties in Libby, Operable Unit (OU) 4 of the Libby Asbestos Superfund Site (Libby Site) in Libby, Montana. The location of Libby, relative to the state of Montana, can be found on Figure 1-1.

The main contaminant of concern at the Libby Site is asbestos. The vermiculite deposit near Libby contains a distinct form of naturally-occurring amphibole asbestos that is comprised of a range of mineral types and morphologies. At the Libby Site, the form of asbestos that is present in the vermiculite deposit is amphibole asbestos that for many years was classified as tremolite/actinolite (e.g., McDonald et al. 1986, Amandus and Wheeler 1987). More recently, the United States Geological Survey (USGS) performed electron probe micro-analysis and x-ray diffraction (XRD) analysis of 30 samples obtained from asbestos veins at the mine (Meeker et al. 2003). Using mineralogical naming rules recommended by Leake et al. (1997), the results indicate that the asbestos at Libby includes a number of related amphibole types. The most common forms are winchite and richterite, with lower levels of tremolite, ~~actinolite,~~ No! ~~and~~ magnesioriebeckite, edenite, and magnesio-arfvedsonite (84, 11, 6, <1% by mass). Because the mineralogical name changes that have occurred over the years do not alter the asbestos material that is present in Libby, and because the United States Environmental Protection Agency (EPA) does not find that there are toxicological data to distinguish differences in toxicity among these different forms, EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, EPA simply refers to the mixture as Libby amphibole asbestos (LA). The term LA refers generally to amphibole materials that originated in the Libby vermiculite deposit, have the ability to form durable, long, and thin structures that are generally respirable, can reasonably be expected to cause disease, and hence are considered the contaminant of concern at the Libby Site.

This RI report includes a comprehensive description of the nature and extent of contamination and a description of past investigative and removal actions within OU4. The subsequent FS report will use the information from the RI to perform a systematic analysis to determine the need for, and scope of, any required remedial action.

During the investigations performed to determine LA exposure levels for the pathways of concern at OU4, LA was observed in all media sampled: air (indoor and outdoor near disturbed soil), vermiculite insulation and bulk materials, indoor dust, soil (surface and subsurface), and water. Current conditions at OU4 are such that vermiculite and LA are present in soil (surface and subsurface) and the interior of residential and commercial buildings (insulation, building materials, dust). Removal actions have begun at some properties at OU4 thereby lessening exposure to LA source materials by removal of the most highly contaminated surface soils, removal of insulation from attic spaces and exposed walls, removal of contaminated dust, and removal or encapsulation of friable building materials. Vermiculite and LA will continue to exist in outdoor soil and indoor source materials if no remedial actions are taken. The details regarding how these conclusions were reached are provided in this RI report.

## 1.1 Report Organization

This RI report is organized according to the format suggested in the *Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response Compensation and Liability Act* (CERCLA) (EPA 1988), and includes the following sections:

- **Section 1 - Introduction.** Provides the purpose and organization of the RI, a brief description of the site location and layout, and a summary of mining and regulatory activities conducted to date at the Libby Site.
- **Section 2 - Study Area Investigations and Removal Actions.** Provides an overview of site investigations and removal actions completed at OU4.
- **Section 3 - Physical Characteristics.** Provides a description of the physical characteristics of the Libby Site. Includes discussion of climate, surface water, geology, groundwater, land use, and demographics.
- **Section 4 - Nature and Extent of Contamination.** Describes the nature and extent of LA contamination within OU4.
- **Section 5 - Summary and Conclusions.** Summarizes the material in the previous sections and provides conclusions drawn from that work.
- **Section 6 - References.** Lists all the references used in the preparation of this RI report.

The human health risk assessment is being prepared separately and will be released at a later date. Therefore, the toxicity of LA, exposure pathways, and associated health risks will not be discussed in this RI report.

## 1.2 Site Background

Numerous hard rock mines have operated in the Libby area since the 1880s, but the dominant impact to human health and the environment in Libby has been from vermiculite mining and processing. Prospectors first located vermiculite deposits in the early 1900s on Rainy Creek, northeast of Libby. Edward Alley, a local rancher, was also a prospector and explored the old gold mining tunnels and digs in the area. Reportedly, while exploring tunnels in the area, he stuck his miner's candle into the wall to chip away some ore samples. When he retrieved his candle, he noticed that the vermiculite around the candle had expanded, or "popped," and turned golden in color.

In 1919, Alley bought the Rainy Creek claims and started the vermiculite mining operation called the "Zonolite Company." While others thought the material was useless, he experimented with it and discovered it had good insulating qualities. Over time, vermiculite became a product used in insulation, feed additives, fertilizer/soil amendments, construction materials, absorbents, and packing materials. Many people used vermiculite products for insulation in their houses and soil additives in their gardens. In 1963, W.R. Grace and Company (Grace) bought the mine and associated processing facilities and operated them until 1990.

conducted

Operations at the mine included blast and drag-line mining and milling of the ore. Dry milling was done through 1985, and wet milling was done from 1985 until closure in 1990. After milling, concentrated ore was transported down Rainy Creek Road by truck to a screening facility (known today as the former Screening Plant) adjacent to Montana Highway 37 (hereafter referred to as Highway 37), at the confluence of Rainy Creek and the Kootenai River. Here the ore was size-sorted and transported by rail or truck to processing facilities in Libby and nationwide. At the processing plants, the ore was expanded or "exfoliated" by rapid heating, then exported to market via truck or rail. Historic maps show the location of the "Zonolite Company" processing operation at the edge of the Stimson Lumber Mill, near present day Libby City Hall. This older processing plant was taken off line and demolished sometime in the early 1950s. The other processing plant (known today as the former Export Plant), was located near downtown Libby near the Kootenai River and Highway 37. Expansion operations at the site ceased sometime prior to 1981, although existing site buildings were still used to bag and export milled ore until 1990.

After operations ceased, Grace completed reclamation of the vermiculite mine. Reclamation included demolition of existing facilities and standard land recontouring and revegetation.

Over the course of Grace's operation in Libby, invoices indicate shipment of nearly 10 billion pounds of vermiculite from Libby to processing centers and other locations. Most of this was shipped and used within the United States. Nearly all of this material ended up in a variety of commercial products that were marketed and sold to millions of consumers. Before the mine closed in 1990, Libby produced approximately 80 percent of the world's supply of vermiculite.

While the mine was in operation, it is estimated that the milling process released more than 5,000 pounds of asbestos into the atmosphere every day. In addition to contamination directly related to vermiculite processing operations, waste products and off-specification materials were made available to the general public on a large scale.

Vermiculite products and wastes were used in thousands of private residences, businesses, and public buildings across the Libby Site. Vermiculite insulation, both commercially purchased and/or obtained otherwise, was used at a high rate in Libby buildings. In the course of Superfund investigations, EPA has encountered vermiculite used as an additive in mortar, plaster, and concrete; as insulation in attic and walls; in soils at depth around septic tanks, tree roots, underground pipe trenches, building foundations; and in surface soils in gardens, yards, driveways, and play areas.

## 1.3 Regulatory History

Asbestos is a hazardous substance as defined by 40 Code of Federal Regulations (CFR) Section 302.4 of the National Oil and Hazardous Substances Pollution Contingency Plan. In November 1999, EPA responded to requests from the State of Montana, Lincoln County Health Board to investigate the potential exposure to asbestos related to the former mine operations and vermiculite processing. The EPA Response Team briefly inspected the former mine and processing facilities, interviewed local officials and members of impacted families, interviewed a pulmonologist in Spokane, Washington, and collected a small set of initial samples. A more detailed summary of initial Libby Site evaluation is found in EPA Action Memorandum, May 23, 2000, *Request for a Time Critical Removal Action Approval and Exemption from the 12-month, $2-million Statutory Limit at the Libby Asbestos Site- Export Plant and Screening Plant former Processing Areas, Libby, Lincoln County, Montana* (EPA 2000a) which is provided in Appendix A. The initial investigation revealed two significant findings:

- There are a large number of current and historic cases of asbestos-related diseases centered around Libby, Montana.
- The likelihood that significant amounts of asbestos-contaminated vermiculite still remained in and around Libby.

These findings led EPA to initiate a larger scale rapid investigation in December 1999 (Phase 1 investigation discussed in Section 2.2) to meet the following goals:

- Obtain information on airborne asbestos levels in Libby in order to judge whether time-critical intervention was needed to protect public health.
- Obtain data on asbestos levels in potential source materials (at the Export Plant and Screening Plant), and identify the most appropriate analytical methods to screen and quantify asbestos in source materials.

Under CERCLA Section 104, EPA has the authority to complete both removal and remedial actions. To date, all cleanups have been conducted using removal action authority to facilitate the timely removal of the most contaminated areas. The initial removal authority for time-critical actions began at the processing areas in May 2000 (EPA 2000a). As additional areas requiring removal were identified, amendments to the initial action memo were approved and are briefly summarized below:

- May 23, 2000 – Initial Action Memorandum approving removal actions at the Export Plant and Screening Plant (EPA 2000a).

Asa Wood too?
no

- July 20, 2001 – Amendment increasing the funding ceiling for continued removal actions at the Export Plant and Screening Plant, and expanding the scope of removal actions to include Rainy Creek Road, Libby High School, Libby Middle, School, Plummer Elementary (now Kootenai Valley Head Start), and two private properties (EPA 2001a). A copy of this document is provided in Appendix A.

- May 2, 2002 – Amendment increasing the funding ceiling and expanding the scope of removal actions to address residential/commercial properties at OU4 (EPA 2002a). A copy of this document is provided in Appendix A.

- May 15, 2006 – Amendment increasing the funding ceiling for additional properties at OU4 (EPA 2006a). A copy of this document is provided in Appendix A.

- June 27, 2006 – Amendment increasing the funding ceiling and expanding the scope of removal actions to include Troy, Montana (EPA 2006b). A copy of this document is provided in Appendix A.

- September 24, 2008 – Amendment increasing the funding ceiling and expanding the scope of removal actions to include specific creeks in Libby and Troy, Montana (EPA 2008a).

- June 17, 2009 – Amendment increasing the funding ceiling for additional residential/commercial removal actions in Libby and Troy, Montana (EPA 2009a). A copy of this document is provided in Appendix A.

- August 4, 2009 – Amendment expanding the scope of removal actions to include the Cabinet View Country Club Golf Course (EPA 2009b). A copy of this document is provided in Appendix A.

In October 2002, the Libby Site was listed on EPA's Superfund National Priority List (NPL), making it eligible to receive additional federal funds for investigation and cleanup, and transition the project from EPA's Removal Program to the Remedial Action Program.

To facilitate a multi-phase approach to remediation of the Libby Site, eight separate OUs have been established. These OUs are shown on Figure 1-2 and include:

- **OU1**. The former Export Plant is defined geographically by the property boundary of the parcel of land that included the former Export Plant and is situated on the south side of the Kootenai River, just north of the downtown area of the City of Libby, Montana. The property is bound by the Kootenai River on the north, Highway 37 on the east, the Burlington Northern and Santa Fe (BNSF) railroad thoroughfare on the south, and State of Montana property on the west.

- **OU2**. OU2 includes areas impacted by contamination released from the former Screening Plant. These areas include the former Screening Plant, the Flyway property, the Highway 37 right-of-way adjacent to the former Screening Plant and/or Rainy Creek Road, and privately owned properties.

- **OU3**. The mine OU includes the former vermiculite mine and the geographic area (including ponds) surrounding the former vermiculite mine that have been impacted by releases from the mine, including the Kootenai River and all creeks in the Libby valley. Rainy Creek Road is also included in OU3. The geographic area of OU3 is based primarily upon the extent of contamination associated with releases from the former vermiculite mine.

- **OU4**. OU4 is defined as residential, commercial, industrial (not associated with former Grace operations), and public properties, including schools and parks in and around the City of Libby, or those that have received material from the mine not associated with Grace operations. A complete listing of all addresses used in this RI report can be found electronically in Appendix B.

- **OU5**. OU5 is defined geographically by the parcel of land that included the former Stimson Lumber Company. OU5 is bound by the high bank of Libby Creek to the east, the Kootenai River to the north, and residential/commercial/industrial property within OU4 to the south and west. This OU is approximately 400 acres in size and is currently occupied by various vacant buildings as well as multiple operating businesses (lumber processing, log storage, excavation contractor, etc.). Within the boundary of OU5 exists the Libby Groundwater Superfund Site, which is not associated with the Libby Asbestos Superfund Site.

- **OU6**. Owned and operated by the BNSF railroad, OU6 is defined geographically by the BNSF property boundaries from the eastern boundary of OU4 to the western boundary of OU7 and extent of contamination associated with the rail yard.

- **OU7**. The Troy OU includes all residential, commercial, and public properties in and around the town of Troy, Montana, approximately 20 miles west of downtown Libby.

- **OU8**. United States and Montana State Highway rights-of-way within the boundaries of OU4 and OU7.

## 1.4 Operable Unit 4 Site Boundary

Establishing OUs at the Libby Site was not straightforward for two primary reasons. First, the dominant mechanism for the spread of contamination was not transport by air or water. At Libby, people spread contamination randomly over a large area by utilizing vermiculite products on their properties, or unknowingly transporting contamination on their clothes or equipment. Thus, there is no obvious, large-scale plume or continuous area of contamination that can be used to establish boundaries. Instead, the Libby Site consists of a large, undefined area with pockets of contamination throughout. Second, while the contamination was most concentrated in Libby, the human actions that spread the contamination were not confined only to the immediate Libby area. In some cases, waste material may have been transported relatively large distances to nearby towns such as Yaak, Eureka, and Kalispell.

Although the delineation of a final site boundary is primarily established after full extent of contamination is determined through the RI process, EPA established an initial study area, as shown on Figure 1-2, to guide sampling activities and provide a general area of concern. EPA developed an initial site boundary for OU4 that:

- Was based upon the conceptual site model which addresses various exposure pathways.
- Included the majority of populated, developed areas in and around Libby where vermiculite products and wastes may have been frequently used.
- Included most locations where vermiculite workers resided (with the exception of Troy) and may have transported contaminated dust on clothes or equipment.
- Excluded outlying areas that were expected to be relatively free of contamination related directly to the vermiculite mine or vermiculite processing. Any impacts in these areas would likely be isolated in nature and of a scale similar to the other parts of the country where vermiculite products may have been used.
- Was based loosely on the geographic boundaries of the Libby valley.
- Would capture the majority, if not all, of any undiscovered, or immeasurable, plume(s) of contamination that may have been aerially dispersed from the vermiculite mine and/or vermiculite processing operations.

Figure 1-3 shows the location of OU4 relative to the former processing areas, schools, parks, and surface waters. Properties outside the OU4 boundary were investigated and/or cleaned up only when specific information was presented that indicated the property might be contaminated and the contamination was suspected to be directly related to vermiculite mining or processing wastes.

Rohs et al is really OMScott in Marysville OH

A better reference is Whitehouse 2004 & 2008 (2006)

## 1.5 Health Effects

Inhalation of asbestos fibers is known to cause several respiratory diseases including pleural thickening, asbestosis, lung cancer, and mesothelioma. Studies by National Institute of Occupational Safety and Health (NIOSH) researchers at the vermiculite mine (Amandus et al. 1987) and Grace sponsored investigations (McDonald et al. 1986) show that workers at the mine had an increased risk of developing asbestos-related lung disease (Amandus and Wheeler 1987, Sullivan 2007, Rohs et al. 2007). 8 appropriate? Whitehouse Additionally, residents may have been exposed to asbestos through handling LA source materials on their property or from inhaling the ambient air while the mine was operational. The significant vertical relief surrounding the Libby valley causes severe and persistent inversion patterns throughout the year. During the mine's operation, the inversion patterns in the valley caused airborne particulates to be suspended for longer periods of time (EPA 2000a). Figure 1-4 illustrates the topography of the Libby valley.

In 2000, the Agency for Toxic Substances and Disease Registry (ATSDR) sponsored asbestos medical screening for former Grace workers from Libby and persons who lived, worked or played in Libby for at least 6 months before December 31, 1990. The study continued into 2001 and included interviews, chest x-rays of participants at least 18 years old, and lung function tests. A total of 7,307 participants were screened over the 2-year period. The study found that 18 percent of x-rayed participants had abnormalities in the lining of their lungs (referred to as pleural abnormalities) (Peipins et al. 2003). The national rate of pleural abnormalities of participants with no known asbestos exposures ranges from 0.2 to 2.3 percent. The study concluded that the prevalence of pleural abnormalities was highest among former Grace workers (51 percent) and the majority of participants reported having multiple routes of exposures (i.e., occupational, recreational, household exposure, other) (ATDSR 2002a).

In December 2000, ATSDR published an initial mortality review of the Libby Site ranging from 1979 to 1998. This comparison of death certificate data to state and national mortality rates showed that there was a 20 to 40 percent increase in malignant and nonmalignant respiratory deaths in Libby over this period. Specifically, asbestosis mortality in Libby was 40 to 80 percent higher than expected and lung cancer mortality was 1.2 to 1.3 times higher. Data on mesothelioma mortality was elevated but difficult to correlate given the infrequent nationwide data on such a rare cancer. Most of the increase in respiratory mortality was associated with occupational exposures (ATSDR 2002b).

In response to the proposal for the Libby Site's inclusion on the NPL in 2002, ATSDR conducted a public health assessment (ATSDR 2003) which is included in Appendix A. The public health assessment evaluated the health implications of the Libby Site using available environmental data, potential exposure scenarios, community health concerns, and health outcome data. The following conclusions are excerpted from the 2002 assessment:

- People in the Libby area were exposed to hazardous levels of asbestos in the past.
- People in the Libby area have elevated levels of disease, and death, associated with exposure to asbestos.
- People could still be exposed to hazardous levels of asbestos near current source areas. These levels could be especially hazardous to sensitive populations, including people who have been exposed for many years already, smokers, and young children.
- The exact level of risk associated with low-level exposure to asbestos cannot be determined due to uncertainties in the analysis and toxicology of LA. Nevertheless, continuing exposures to LA pose an unacceptable risk to residents and workers who have already been exposed for many years.

- The cleanup actions undertaken by EPA are protective of public health.

Since 1999, EPA has been performing removal actions at OU4 to address the most contaminated areas and decrease the exposure pathways at residential properties and public areas. In June 2009, EPA declared a public health emergency in Libby highlighting the need for continued cleanup efforts as well as medical screening and treatment resources for affected residents.

At the time of this report, medical researchers from Mount Sinai, the University of Montana, Idaho State University and Libby's Center for Asbestos Related Disease began a 5-year study to investigate long-term health effects of human exposure to LA contaminated vermiculite ore. The study will examine asbestos risks during childhood, lung scarring among Libby residents not directly involved in vermiculite mining, and the relationship between lung scarring and autoimmune disorders. Additional research in small mammal exposure and pathologic assessment of lung tissue from exposed individuals is planned to quantify the health risks to Libby residents from exposure to LA through internal dosimetry and LA toxicity.

# Section 2
# Site Study Area Investigation and Removal Actions

Multiple investigation, pre-removal, and removal events have occurred at OU4. This section discusses each of the events and presents analytical data and observations relevant to the risk assessment and FS. Discussions in this section are grouped by phase (investigation, design, removal) then arranged chronologically thereafter. Several atypical properties have warranted specialized contamination assessments and those properties are not included in the overall summary of the initial contamination assessments (i.e., Phase 1 and/or Contaminant Screening Study [CSS]). Each of the following events is summarized in this section:

| Investigation/Action | Activity Description | Activity Lead |
|---|---|---|
| **1999 – 2009** | **Investigations** | |
| 1999 | Phase 1 | EPA |
| 2001 | Phase 2 | EPA |
| 2002- | Contaminant Screening Study | EPA |
| Various | Contamination Assessments at Special Properties | EPA |
| 2002 | Natural Resource Conservation Service | EPA |
| 2002 | Sediment Core Pilot Study | EPA |
| 2003 | Post Cleanup Evaluation | EPA |
| 2005 | Supplemental Remedial Investigation | EPA |
| 2005 | Cumulative Risk Assessment | EPA |
| 2006 | Outdoor Ambient Air Program | EPA |
| 2007 | Dust Pilot Study | EPA |
| 2007 | Residential Activity-Based Sampling | EPA |
| 2008 | Libby Background Soil Study | EPA USGS? |
| 2008 | School Investigation | EPA |
| 2009 | School Activity-Based Sampling | EPA |
| **2003 – 2009** | **Removal Design** | |
| **2001 – 2009** | **Removal Actions** | |

### *OU4 Sample Dataset*

Over the 10-year period of remedial investigations and removal actions at OU4, more than 70,000 samples have been collected of air (indoor, outdoor ambient, and outdoor near disturbed soil), vermiculite insulation and bulk materials, indoor dust, soil (surface and subsurface), and water. Only those samples with analytical results are discussed in this RI report. Additionally, data in the project database, is constantly fluctuating as new analytical results are received and previous results are revised. All data presented in this report ~~is~~ are based on a database snapshot dated November 24, 2009.

Although many of the investigations described in Section 2 included properties outside OU4, only the samples that were collected from properties within OU4 are included in the dataset for this RI report and summarized in the discussion below. A complete listing of all addresses used in this RI report can be found electronically in Appendix B. note that these are on CD

huh? Due to the volume of samples collected, detailed analytical results are only presented for smaller-scale investigations. Additionally, this report only presents the analytical results for LA. Sample-related information and associated analytical results, including detections of chrysotile asbestos, can be found electronically for each sample in Appendix C.

PCME vs total LA

Samples that have been collected in adherence with health and safety requirements, as outlined in the *Comprehensive Site Health and Safety Program* (CDM Federal Programs Corporation [CDM] 2006a), are not discussed in this report. The majority of these samples are personal air samples that were collected to demonstrate the protectiveness of the respiratory protection used by field personnel during investigation and removal activities. Additionally, samples that do not characterize the contamination inherent to a property but have been collected to ensure contamination has not migrated as a result of project operations (i.e., air monitoring at the landfill, air monitoring in decontamination trailers, bulk material samples of decontaminated personal protective equipment (PPE), bulk material samples of landfill vehicle air filters) have also been included in the health and safety dataset. Landfill operations are governed by the *Lincoln County Class IV Asbestos Landfill Operations Plan, Revision 2* (CDM 2008a) and are not summarized in detail in this report. Sample-related information and analytical results of samples associated with health and safety or project operations can be found electronically in Appendix D, and copies of both documents are provided in Appendix A.

Outdoor stationary air samples collected during a removal action (to ensure adequate dust suppression was implemented), and any bulk, indoor air, and water samples collected after removal action are not discussed in this report. Rather, it is assumed that all clearance or confirmation samples collected during the removal program satisfied the clearance sample criteria, as described in Section 2.20.1, before the removal was considered complete. Sample-related information and analytical results of samples associated with the removal program can be found electronically in Appendix E.

Field quality control (QC) samples that are intended to assess sample handling and decontamination procedures (e.g., field blanks, lot blanks, dry blanks, and equipment blanks) are not included in the OU4 dataset and are discussed separately in Section 2.22. Sample-related information and analytical results for QC samples can be found in Appendix F. Soil field duplicates and soil field splits were collected to evaluate the heterogeneity of the sampled areas and have been used in identifying contaminated soil for removal actions. Therefore, field duplicates and soil splits are included in the OU4 dataset and are discussed within the respective investigation-specific sections of this report.

The finalized OU4 dataset, included in Appendix C, details the LA contamination at OU4 by media. Soil samples were designated as either surface or subsurface samples based on the top depth provided in the project database. The top depth of a surface soil sample is less than or equal to 3 inches below ground surface (bgs); the top depth of a subsurface soil sample is greater than 3 inches bgs. The bottom depth of soil sample collection was not a determining factor.

Figures 2-1 through 2-8 show the locations of OU4 investigation and design samples, separated by media type. Although more than one sample is typically collected per property, these figures represent one sample location per property. Additionally, each figure annotates the number of properties with sufficient GPS data to be represented. Detections of LA are presented by media and per property on Figures 2-9 through 2-16.

## 2.1 Summary of Analytical Methods

EPA employed commercial asbestos test methods for air, bulk material, soil, dust, and water samples collected at OU4, as discussed in this section. When necessary, the analytical methods were incorporated into project-specific standard operating procedures (SOPs) or modified to meet the data reporting needed to support project decision making. word? Detailed descriptions of project-specific analytical SOPs, and standard and modified commercial test methods, as well as the application of these SOPs and methods are presented in the *Draft Analytical Methods Summary for Operable Unit 4* (CDM 2009a) which is provided in Appendix A. In some instances, EPA conducted pilot studies or performance evaluation (PE) studies to ensure the successful implementation of a sample collection, processing, or analytical technique. Specifics of those studies are detailed in other EPA documents (e.g., the *Draft Analytical Methods Summary for Operable Unit 4*) and are only generally summarized in this report.

The following analytical methods used to analyze OU4 samples are discussed herein:

**Air:**

- Phase contrast microscopy (PCM) in accordance with NIOSH 7400
- Transmission electron microscopy (TEM) in accordance with the Asbestos Hazard and Emergency Response Act (AHERA); hereafter referred to as TEM AHERA

- TEM in accordance with International Organization for Standardization (ISO) 10312; hereafter referred to as TEM ISO

**Dust:**

- American Society of Testing and Materials (ASTM) D5755, following TEM AHERA
- ASTM D5755, following TEM ISO

**Soil:**

- Polarized light microscopy (PLM) in accordance with NIOSH 9002 (hereafter referred to as PLM-9002)
- PLM-visual estimation (PLM-VE)
- PLM-Gravimetric, hereafter referred to as PLM-Grav
- EPA 600

**Vermiculite Insulation and Bulk Materials:**

- PLM-9002

**Water:**

- EPA 100.2
- TEM ISO (prior to the adoption of EPA 100.2)

### 2.1.1 PCM

The PCM NIOSH method 7400, Issue 2, *Asbestos and Other Fibers by PCM* (NIOSH 1994a), is a traditional technique used for the measurement of asbestos fibers in air. PCM is an estimation method and cannot be used to differentiate between asbestos and non-asbestos fibers. PCM techniques are not as sensitive as TEM. Some asbestos fibers with dimensions below the resolution of PCM techniques are detectable by TEM and are believed to have a hazardous potential (i.e., the toxicity of long thin fibers is greater than that of shorter thicker fibers) (Berman et al. 1995). PCM measurements of asbestos fiber concentrations, however, have been used for most historical human health data and many occupational exposure regulatory limits. EPA has adopted this method, with modification, at OU4 for most personal air monitoring for Occupational Safety and Health Administration (OSHA) compliance.

### 2.1.2 TEM Methods

TEM methods are more complex than PCM and require the use of a more sophisticated analytical instrument that can distinguish between asbestos and non-asbestos fibers and asbestos types. TEM methods can be used on dust, air, and solid media, and include TEM AHERA, TEM ISO, ASTM D5755, and EPA 100.2.

#### 2.1.2.1 TEM AHERA

*Appendix A to Subpart E of 40 CFR Part 763, EPA's Interim Transmission Electron Microscopy Analytical Methods - Mandatory and Nonmandatory - and Mandatory Section to Determine Completion of Response Actions* (EPA 1987) contains the minimum requirements for air sample analysis for asbestos by TEM. At OU4, EPA has adopted this method, with modification, for most non-risk based air and most dust sampling data.

#### 2.1.2.2 TEM ISO 10312

The *TEM ISO 10312 Ambient air - Determination of Asbestos fibers - Direct-transfer Transmission Electron Microscopy Method* was issued in 1995 (ISO 1995). This TEM method is suitable for determining the concentration of asbestos structures in both indoor and outdoor air environments and includes measurement of asbestos structure lengths, widths, and aspect ratios. The method can be used to determine the type(s) of asbestos fibers present but cannot be used to discriminate between individual fibers of the asbestos and non-asbestos analogues of the same amphibole mineral. EPA has adopted this method, with modification, primarily for OU4 risk-based air sampling data.

### 2.1.3 ASTM D5755

The ASTM method D5755-95, *Standard Test Method for Microvacuum Sampling and Indirect Analysis for Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations* (ASTM 2003) is a procedure to identify asbestos in dust and provide an estimate of the surface loading of asbestos in the sampled dust. Based on findings of a pilot study conducted in 2005 (EPA 2005a), traditional dust sample preparation processes were improved upon by consistently ashing the dust samples prior to analysis. EPA continues to use the ASTM D5755 method, with modification, to analyze OU4 dust samples, although dust sample collection was suspended in 2007. Depending on the analytical requirements of each investigation, dust sample analysis has fluctuated between TEM AHERA and TEM ISO.

### 2.1.4 PLM 9002

The PLM NIOSH 9002, Issue 2 method for the determination of asbestos (bulk) by PLM (i.e., PLM-9002) was released in 1994 (NIOSH 1994b). According to the method, PLM-9002 is useful for the qualitative identification of asbestos and the semi-quantitative determination of asbestos (meaning that the asbestos types can be differentiated) content of bulk samples for concentrations above 1 percent. Method level of detection below 1 percent is detectable but not measureable with good precision. The analyst measures percent asbestos with comparison to standard area projections, photographs, drawings, or trained experience. This method is not applicable to samples containing large amounts of fine fibers below the resolution of the light microscope; however, it is useful for confirmation of LA in soil samples for which quick turnaround analysis is required (e.g., for removal actions).

### 2.1.5 Site-Specific PLM Method

#### 2.1.5.1 Performance Evaluation Study

In early 2002 at the onset of the RI CSS, EPA recognized that existing soil analytical methods, such as PLM-9002, were inadequate for measuring low concentrations of LA below 1 percent with more than 5 percent accuracy. EPA thus began researching a more accurate soil analytical method. Additionally, the cost and turnaround time of any new methods was of concern, given the need to screen the thousands of soil samples planned to be collected under the CSS.

To address these issues, EPA, with assistance from the USGS and Syracuse Research Corporation (SRC), designed and implemented a soil PE study. The objectives of the PE study were to:

- Develop PE test materials of known, verified LA concentrations in soil that could be used to test the efficacy of soil analytical methods.
- Use the PE test materials to evaluate multiple commercially available analytical methods and technologies to determine their suitability for detecting and measuring LA in soil at various concentrations and under conditions similar to those found at the Libby Site.
- Based upon these results, develop and refine project-specific test methods to detect low concentrations of LA in soil.
- Based upon the results, develop a set of acceptance criteria for the PE test materials.
- Use PE test materials as a quality control tool for testing the performance of analytical laboratories.

The PE study was conducted in several test phases, with the majority of the work conducted in 2002. The details of the phased approach are described in the *Quality Assurance Project Plan, Performance Evaluation Study for Analytical Methods in Soil, Part B, Revision 1* (EPA 2003a) which is provided in Appendix A. While the PE study was underway, soil samples collected as part of the CSS were held without analysis. During 2003, following the interim results of the PE study, EPA released the CSS soil samples for analysis using a newly developed project-specific PLM method - PLM-VE. The PLM-VE method, which is based on PLM-9002 but employs visual area estimation, has been used since 2003 for OU4 investigation soil samples because of its reliability to detect low concentrations of LA in soil to 0.2 percent in a cost-effective, rapid manner. The details of the PE study are summarized in a separate PE study report prepared by SRC and in review at EPA. where
where

### 2.1.5.2 Soil Processing

In preparation for PLM-VE analysis, soil samples were processed in accordance with the current version of ISSI-LIBBY-01, *Soil Sample Preparation* (SRC 2007a). In brief, the raw soil sample is dried and split into two aliquots. One aliquot is placed into archive, and the other aliquot is sieved into coarse (greater than ¼-inch) and fine fractions. The fine fraction is ground to reduce particles to a diameter of 250 microns (µm) or less and this fine-ground portion is split into four additional aliquots. The fine-ground and coarse aliquots were analyzed by PLM-VE and PLM-Grav, respectively, as described below.

As a more precise analytical method was implemented (PLM-VE), approximately 1,600 soil samples initially analyzed by PLM-9002 were retrieved from archive, sent through the grinding step, and reanalyzed. Approximately 60 percent of the Phase 1 soil samples with non-detect LA results by PLM-9002 were processed and reanalyzed using PLM-VE. In general, Phase 1 investigation soil samples with detectable levels of LA were not reanalyzed because these results were considered usable for decision making purposes.

Additionally, a limited number of Phase 1 soil samples were renumbered with a different sample index number, ground, and reanalyzed by EPA 600/R-93/116 (EPA 1993) rather than PLM-VE. EPA 600 R-93/116 is a PLM method for determining asbestos in bulk building materials; however, as documented in Laboratory Modification LB-000018, is interchangeable with PLM-VE for the point counting approach.

QC procedures implemented at the soil processing facility are generally described in Section 2.22.2.

### 2.1.5.3 PLM-VE

The PLM-VE method, SRC-LIBBY-03, *Analysis of Asbestos Fibers in Soil by PLM* (SRC 2003) was round-robin tested as part of a 2002 EPA PE Study and issued in 2003. PLM-VE, based on PLM-9002, EPA 600/R-93/116, and California Air Resource Board (CARB) Method 435 (CARB 1991), is a semi-quantitative method that provides a standard approach to quantify all types of asbestos fibers including chrysotile and amphiboles like those characteristic of the Libby Site using visual estimation or point counting techniques. For the visual estimation technique, guidance is provided on the classification of asbestos mineral type and the estimation of LA mass percent using site-specific reference materials following project specified "bin" categories. For point counting, the SOP provides guidance on how to estimate mass percent of LA present. The method is suitable for use on the fine fraction of soil and other similar soil-like media that has been processed using ISSI-LIBBY-01, *Site-Specific SOP for Soil Sample Preparation* (e.g., CSS and pre-design inspection [PDI] samples).

PLM-VE results are reported using a multi-bin classification system based upon visual area estimation of the amount of LA present in the soil. This approach generates a "semi-quantitative" result that estimates the concentration range, but does not assign a single concentration value to the result. Because reference materials of known LA concentration are used by the analyst to identify the bin range concentration of the fine-ground field sample, results are reported in terms of concentration bins, defined by ranges of %LA (by mass). The PLM-VE concentration bins are defined in the method as:

| | |
|---|---|
| Bin A: | No LA detected. Bin A results are generally recorded by the analyst as "ND" for non-detect. |
| Bin B1: | LA detected, but at a level estimated to be lower than 0.2%. Bin B1 results are generally recorded by the analyst as "Trace." |
| Bin B2: | LA detected at a concentration estimated to be less than (<) 1% but greater than or equal to (≥) approximately 0.2%. Bin B2 results are generally recorded by the analyst as "<1%." |
| Bin C: | LA detected at a concentration estimated to be ≥1%. Bin C results are generally recorded by the analyst as "1%," "2%," etc. |

### 2.1.5.4 PLM-Grav

The PLM-Grav method, SRC-LIBBY-01, *Qualitative Estimation of Asbestos in Coarse Soil by Visual Examination Using Stereomicroscopy and Polarized Light Microscopy* (SRC 2002a) was developed in 2002 and contains elements from PLM-9002 and EPA 600/R-93/116. The PLM-Grav SOP provides a screening method to examine the coarse fraction of a sieved sample with particle size greater than ¼ inch for evidence of asbestos mineral content using stereomicroscopy with confirmation of asbestos by PLM-9002. As the name implies, units of measure for the course fraction are given in %LA (by mass). However, the analytical sensitivity for the PLM-Grav is lower than the PLM-VE method.

The method is suitable for use on soil and other similar soil-like media to quantify all types of asbestos fibers, including chrysotile and amphiboles like those characteristic of the Libby Site. Unlike the semi-quantitative results generated by the PLM-VE method, the PLM-Grav method generates fully quantitative results. As such, care should be taken when comparing and contrasting analytical results between the PLM-Grav and PLM-VE methods.

## 2.1.6 EPA 100.2

The *Determination of Asbestos Structures over 10 μm in Length in Drinking Water* method was issued in 1994 and is referenced using the designation EPA 100.2 (EPA 1994). This TEM method is used to determine the presence and quantification of asbestos structures in water samples, and has been adopted by EPA, with modification, to analyze Libby Site water samples.

Need Transition ¶ that outlines the discussion of all of the subsequent investigative phases— an enhanced version of the table on 2-1 A road map of where we are going



## 2.2 Phase 1

Phase 1 investigation field sampling was completed in accordance with the *Phase 1 Sampling and Quality Assurance Project Plan* (EPA 1999) and *Phase 1 Sampling and Quality Assurance Project Plan, Revision 1* (EPA 2000b). These documents are interchangeably referred to as the *Phase 1 QAPP*, and the latest version is provided in Appendix A. While the initial Phase 1 investigation was primarily conducted from 1999 to 2002, the procedures contained in the *Phase 1 QAPP* have been used to collect various characterization data since 2002, and are still in use for non-routine sampling requests and routine health and safety monitoring at the Libby Site. This section summarizes the initial Phase 1 data on which development of the CSS was based, and the subsequent Phase 1 data collected at OU4 to date.

### 2.2.1 Initial Phase 1 Investigation

The initial Phase 1 investigation for OU4, implemented between December 1999 and March 2002, was designed as a rapid pilot-scale investigation with two main objectives:

1) Determine airborne asbestos levels in Libby in order to judge whether a time-critical intervention is needed to protect public health.

2) Obtain data on asbestos levels in source materials to determine the most appropriate analytical methods.

Sampling focused on indoor and outdoor ambient air, vermiculite insulation and building materials, indoor dust, and outdoor surface and subsurface soils in order to meet these objectives. Investigation water samples were also collected on a very limited basis. Each of these media is discussed and summarized herein.

A total of 246 ambient air samples were collected during initial Phase 1 investigation activities. Summary information for the indoor and outdoor sample results is presented below:

| Initial Phase 1 Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor Ambient | TEM ISO | 200 | 118 | 83 | 1 – 105 | 0.00025 – 0.53814 s/cc |
| | TEM AHERA | 1 | 0 | 1 | 1 | 0.00176 s/cc |
| | PCM* | 21 | 13 | 8 | - | 0.003 – 0.193 f/cc |
| Outdoor Ambient | TEM ISO | 27 | 24 | 3 | 1 | 0.00011 – 0.00030 s/cc |
| | PCM* | 1 | 1 | 0 | - | - |

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; AHERA – Asbestos Hazard Emergency Response Act; PCM – phase contrast microscopy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter

One hundred Phase 1 vermiculite insulation samples were collected from various OU4 properties prior to April 2002. Sample results are summarized as follows:

| Initial Phase 1 Vermiculite Insulation Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Grab | PLM-9002 | 100 | 27 | - | 66 | - | 7 |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

During the initial Phase 1 investigation, a total of 47 samples of bulk building materials were collected at OU4 properties. Sample results are compiled below:

| Initial Phase 1 Bulk Materials Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Grab | PLM-9002 | 47 | 41 | - | 5 | - | 1 |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

In total, 2,067 indoor dust samples were collected during the initial OU4 Phase 1 investigation. Summary information for the dust results is as follows:

| Initial Phase 1 Dust Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor | TEM ISO | 2,067 | 1,758 | 309 | 1 – 89 | 30 – 566,120 s/cm$^2$ |
| | TEM AHERA | 23 | 22 | 1 | 1 | - 474 s/cm$^2$ |

Notes: LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; AHERA – Asbestos Hazard Emergency Response Act; s/cm$^2$ – structures per square centimeter

In total, 1,673 soil samples were collected during initial Phase 1 activities. One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. The following table summarizes the soil sample results:

| Initial Phase 1 Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 1,630 | 1,138 | - | 447 | - | 45 |
| | PLM-VE | 828 | 714 | 93 | - | 14 | 7 |
| | PLM-Grav | 454 | 440 | 13 | - | - | 1 |
| Subsurface | PLM-9002 | 22 | 19 | - | 2 | - | 1 |
| | PLM-VE | 11 | 10 | 1 | - | - | - |
| | PLM-Grav | 10 | 10 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

Two investigatory water samples were collected at an OU4 property to determine the presence of LA. Results by TEM ISO indicate one LA structure was present in one of the samples, while the other was non-detect for LA (Appendix C). Concentration data is not available for these samples.

Based on the initial Phase 1 data collected, it was determined that a time-critical intervention for airborne asbestos levels in Libby was not required to protect public health. However, results of initial Phase 1 sampling did prompt the removal of major LA sources at various properties in and around Libby including the former Screening Plant (OU2), former Export Plant (OU1), Kootenai Development Corporation (KDC) Bluffs (Section 2.5.1), KDC Flyway (OU2), Kootenai Valley Head Start (Section 2.5.2), Libby High School (Section 2.5.5), Libby Middle School (Section 2.5.4), and several residential and commercial properties.

Preliminary work of the Phase 1 investigation did not provide enough information to determine appropriate soil analytical methods; therefore, additional work related to analytical method development was conducted under subsequent investigation efforts. The soil PE study is discussed in Section 2.1.5.1 and the *Draft Analytical Methods Summary for Operable Unit 4* (CDM 2009a).

Additionally, a review of the Phase 1 data showed that LA-contaminated materials were used randomly at unknown properties in the past, and EPA determined that each property in the Libby valley required screening for potential sources of LA. However, as a result of the size of the Libby Site and the number of properties that needed to be evaluated, emphasis needed to be placed on an investigative approach that minimized sampling and analysis to identify areas requiring remediation. The sampling program developed to address these objectives is referred to as the CSS and is discussed in Section 2.4.

The initial Phase 1 work yielded information critical to developing the procedures used in the CSS, as documented in the following technical memoranda produced by SRC. These memoranda can be found in Appendix A of the *Final Sampling and Analysis Plan (SAP), Remedial Investigation Contaminant Screening Study* (hereafter referred to as the *CSS SAP* [CDM 2002a]) which is provided in Appendix A of this report.

- Technical Memorandum 1 concluded that the presence of visible vermiculite in soil at the Libby Site is a reliable and useful indicator of the presence of elevated levels of asbestos; therefore no soil samples were required to be collected in areas where visible vermiculite was observed during the 2002 CSS.

- Technical Memorandum 2 concluded that sampling bulk vermiculite insulation was not necessary due to the elevated frequency of LA in insulation; therefore, no vermiculite insulation samples were collected during the 2002 CSS.

- Technical Memorandum 3 concluded that it is reasonable to perform indoor dust removal at buildings containing vermiculite insulation, without basing indoor dust removal decisions on the results of dust samples. Therefore, beginning with the 2002 CSS, dust samples were typically not collected from buildings in which vermiculite insulation was observed.

### 2.2.2 Subsequent Phase 1 Investigation

Since the completion of initial Phase 1 data collection activities in March 2002, additional general investigation sampling has been conducted throughout OU4 with the primary purpose of identifying or quantifying LA. The data may also be used to guide removal decisions. The *Phase 1 QAPP* (EPA 2000b) governs the collection of these samples, as well as the collection of samples not specified under other field sampling plans (i.e., non-routine requests).

Phase 1 samples collected at OU4 subsequent to March 2002 include the following: indoor ambient air, bulk building materials, indoor dust, outdoor surface and subsurface soil, and well water. It should be noted that, as mentioned previously, Technical Memorandum 2 provided rationale for discontinuing the collection of bulk vermiculite insulation samples. However, sampling of building materials continued at

OU4 on a somewhat limited basis after March 2002, and is still conducted as part of PDI activities to guide removal decisions (Section 2.18.3).

Since March 2002, 120 indoor ambient air samples were collected at OU4. Samples were predominantly collected to provide information about ambient levels of LA in indoor air prior to and immediately following indoor removal activities conducted by EPA. No Phase 1 outdoor ambient air samples were collected at OU4 after March 2002.

The indoor ambient air sample results are compiled as follows:

**Subsequent Phase 1 Air Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | |
|---|---|---|---|---|---|---|
| | | | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor Ambient | TEM ISO | 12 | 10 | 2 | 1 | 0.00085 – 0.00441 s/cc |
| | TEM AHERA | 16 | 5 | 11 | 3 | 0.00182 – 0.03230 s/cc |
| | PCM* | 21 | 2 | 19 | - | 0.003 – 0.122 f/cc |

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; AHERA – Asbestos Hazard Emergency Response Act; PCM – phase contrast microscopy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter

Following the initial Phase 1 sampling period, a total of 113 samples of building materials were collected at OU4 properties. Data from this sampling was primarily used to guide removal decisions. Sample results are summarized in the following table:

not all vermiculite contains LA?

**Subsequent Phase 1 Bulk Building Material Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Grab | PLM-9002 | 113 | 99 | - | 9 | - | 5 |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

In total, 2,067 Phase 1 indoor dust samples were collected after March 2002. Summary information for the dust results is as follows:

| Subsequent Phase 1 Dust Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor | TEM AHERA | 14 | 12 | 2 | 0 – 3 | 88 – 1,327 s/cm$^2$ |

Notes: LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; AHERA – Asbestos Hazard Emergency Response Act; s/cm$^2$ – structures per square centimeter

After the initial Phase 1 soil sample collection evented, a total of 175 soil samples were collected at OU4. One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Sample results are summarized as follows:

| Subsequent Phase 1 Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 147 | 130 | - | 12 | - | 5 |
| | PLM-VE | 25 | 19 | 5 | - | 1 | 0 |
| | PLM-Grav | 16 | 16 | 0 | - | 0 | 0 |
| Subsurface | PLM-9002 | 20 | 16 | - | 1 | - | 3 |
| | PLM-VE | 3 | 1 | 1 | - | 0 | 1 |
| | PLM-Grav | 1 | 1 | 0 | - | 0 | 0 |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

In September 2006, two investigatory water samples were collected at an OU4 property to determine the presence of LA. Results by EPA 100.2 were both non-detect for LA (Appendix C).

## 2.3 Phase 2

Phase 2 investigation field sampling was conducted in the Fall of 2001 and completed in accordance with the *Phase 2 Sampling and Quality Assurance Project Plan* (EPA 2001b). Specifics on sample collection procedures and conclusions of the Phase 2 investigation work were detailed in the *Draft Phase 2 Summary Report* (EPA 2006c), and summarized below. The entire Phase 2 data set is included in Appendix C, and copies of both documents are provided in Appendix A.

The objectives and major conclusions of the Phase 2 field investigation were:

**Objective 1:** Determine what method is best for collection of air samples through the collection of samples that measure asbestos levels in the breathing zone of individuals engaged in routine and special activities in and about Libby, and to compare those measurements to data collected from co-located stationary air monitors in order to help guide future air sampling activities at the Libby Site that are needed to evaluate risks to individuals engaged in both routine and unique activities in the house.

**Conclusion 1:** Stationary air monitors may tend to underestimate exposure and risk of individuals who engage in activities that disturb asbestos-containing source material. The magnitude of the underestimation depends upon the scenario; scenarios that are associated with routine activities and minimal disturbances are associated with only small differences (ratios close to 1), while scenarios that are associated with active disturbances are associated with the greatest differences (ratios above 1). The absolute magnitude of the difference between a pair of stationary and personal samples is expected to be highly variable between different settings, depending on the intensity and duration of disturbance activities, the nature of the source material, the speed and direction of wind or air flow in the vicinity, and the distance between the activity and the stationary monitor.

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**Objective 2:** Determine what method of analysis is best for air samples through analysis of a series of different air samples by both the TEM and PCM methods in order to help judge which type of measurement is most appropriate, and to derive a site-specific relationship between the two (if possible). In particular, the goal was to address two questions related to differences between PCM and TEM: 1) Does PCM overestimate asbestos concentrations relative to TEM, because PCM does not distinguish between asbestos and non-asbestos fibers in a sample? and 2) Does PCM underestimate asbestos concentrations relative to TEM, because PCM cannot visualize structures thinner than about 0.25 μm in thickness and does not include structures shorter than 5 μm?

**Conclusion 2:** The use of PCM will usually tend to overestimate exposure of individuals who engage in activities that disturb asbestos-containing source material, especially in residential environments, since a number of non-asbestos fibers will be included. Conversely, use of PCM will tend to underestimate exposure to total LA, since about 55 percent of all LA structures are either too thin or too short to count by PCM. Because the relationship between PCM and TEM varies with the setting of the activity, the type of source material, and the location of the air monitor, it is not possible to establish a default site-specific relationship between the two methods.

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**Objective 3:** Determine if the levels of asbestos observed in Libby are of potential human health concern through the analysis of the data collected to derive preliminary assessments of the potential health risk to people who engage in the types of routine and special activities investigated during the study. It is important to note that, because the Phase 2 study was not intended to be systematic or comprehensive and hence did not span all possible exposure conditions and all exposure locations, the project plan emphasized that the data should be interpreted as providing only an initial estimate of the range of different exposure levels (and hence health risks) that residents of Libby may experience from both routine and special activities.

**Conclusion 3:** In general, the levels of LA in air tend to be highly variable over time and space. This emphasizes the need to collect additional data on the levels of LA that occur in association with a wide range of activities and at a wide range of locations in order to better understand the exposures and risks which may be occurring at the Libby Site.

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Additional conclusions for the Phase 2 investigation were derived during the data analysis. These conclusions were not based on primary investigation objectives, but have provided additional guidance on the design of all investigations conducted at the Libby Site since the Phase 2 investigation was completed. These additional conclusions include the following:

**Conclusion 4:** Concentration values in most samples of air and dust are in a range where TEM analysis based on only 10-20 grid openings is likely to identify only a relatively small number of LA particles. Because there is high analytical uncertainty associated with a small number of detected particles, future sampling efforts should seek to increase the number of grid openings evaluated to the extent allowed by time and cost constraints. This will increase sensitivity and decrease uncertainty in concentration, exposure, and risk estimates.

**Conclusion 5:** The data collected during Phase 2 were not adequate to derive any meaningful estimates of transfer factors for LA from soil to outdoor air, soil to indoor dust, or indoor dust to indoor air. This is mainly because of the high variability in soil, dust, and air values, coupled with a relatively low analytical sensitivity and a resultant high frequency of non-detects for most Phase 2 samples. It should be noted that additional investigations (Section 2.9) have attempted to determine these transfer factors without success.

*Study Design*

The general investigation design was to investigate the concentrations of asbestos fibers in air that may occur in the breathing zone of individuals engaged in a variety of activities that might lead to the disturbance of asbestos-contaminated source materials such as dust, vermiculite insulation, and soil. To this end, Phase 2 was divided into four general activity-based "scenarios," as follows:

**Scenario 1 - Routine Household Activities**: Scenario 1 focused on the airborne exposures of residents engaged in routine household activities excluding active cleaning. A total of 16 residences participated in Scenario 1. This included residences with and without vermiculite insulation, and residences with and without measured levels of asbestos in indoor air and dust. The types of activities performed during the sample collection period were recorded by the resident in an activity log. Any special activities that were a potential source of increased exposure to airborne asbestos fibers were also recorded in the activity log.

**Scenario 2 - Active Household Cleaning Activities**: Scenario 2 focused on active cleaning-related activities (vacuuming, sweeping, dusting) that are likely to cause increased levels of dust (and hence asbestos) in indoor air. A total of 22 residences participated in Scenario 2 (these residences included 13 of the 16 locations participating in Scenario 1). In addition to the cleaning activities of vacuuming, sweeping, and dusting, an additional cleaning scenario was evaluated at one residence to assess exposures specifically related to beating sofa cushions. Vacuuming/sweeping/dusting cleaning activities are referred to as Scenario 2A and beating sofa cushions is referred to as Scenario 2B.

**Scenario 3 - Active Disturbance of Vermiculite**: Scenario 3 focused on exposures that occur when vermiculite sources are actively disturbed, such as when a contractor performs remodeling or repair work in a house with vermiculite insulation, or when a resident enters a space (e.g., an attic area) with unenclosed vermiculite insulation. Seven residences participated in Scenario 3. Six of these seven residences had vermiculite insulation in the attic, and samples of insulation from all six of these attics contained detectable levels of LA when examined by PLM. Scenario 3 exposure activities were separated into the following categories:

- 3A) Sweeping or moving debris/insulation in attic
- 3B) Cutting holes into ceilings or walls (e.g., replacing a ceiling fan)
- 3C) Replacing or removing carpeting
- 3D) Removing vermiculite insulation via hand-bagging
- 3E) Removing vermiculite insulation via vacuum truck

**Scenario 4 - Active Disturbance of Soil (Rototilling Activities)**: Scenario 4 focused on exposures that occur when garden soil is actively disturbed during rototilling activities. This scenario was chosen both because vermiculite is known to have been added to a number of gardens in Libby, and because rototilling is a realistic and aggressive soil disturbance scenario. While the Phase 2 QAPP specified that rototilling was to be performed for three gardens (one garden without visible vermiculite and two gardens with visible vermiculite), the activity was only completed in one garden with visible vermiculite.

### 2.3.1 Air

There were several types of air monitoring samples collected during the Phase 2 study. The sections below summarize the different types of air samples collected and the timing of the sample collection. Refer to Appendix C for additional information on individual sample details and analytical results.

For each of the activity-based scenarios, air samples that were collected can be categorized into three general time intervals: pre-activity, during activity, and post-activity. In general, the samples of greatest interest are those collected during the activity, since these provide data on the level of LA in air associated with the activity. Stationary samples collected before or after the activity were used mainly to establish a frame of reference for evaluating the sample collected during the activity. Personal air samples collected before and after the various activities were mainly intended for the purposes of ensuring worker protection, and may not be representative of air concentrations likely to be inhaled by residents. Thus, these samples were not evaluated further.

***Stationary Air Samples***

Phase 2 stationary air samples were collected during a series of both indoor and outdoor scenario activities as described above. Stationary air monitors were placed in the main area(s) of the residence where scenario-related activities were occurring. During Scenarios 2 and 3, several outdoor stationary air samples were also collected to monitor for potential releases of contaminated materials during scenario-related activities. For Scenario 4, the stationary air monitors were placed in four locations surrounding the perimeter of the rototilling activity. Stationary air samples were collected in accordance with EPA-LIBBY-01, *SOP for the Sampling of Asbestos Fibers in Air, Revision 1*. Phase 2 stationary pre- and post-activity air sample filters were prepared for PCM, TEM AHERA, and TEM ISO analyses. TEM AHERA and TEM ISO (10 grid openings initially) were completed, followed by PCM analysis and additional grid openings on the TEM ISO analyses unless EPA suspended the need for the analyst to read additional grid openings on particular samples.

In addition, Phase 2 stationary clearance samples were collected to establish when the house was suitable for re-occupation by the resident after scenario activities were complete. Three sequential clearance samples were collected after the scenario activities were completed. Similar to stationary samples, clearance samples were collected in accordance with EPA-LIBBY-01, *SOP for the Sampling of Asbestos Fibers in Air, Revision 1*. Clearance samples were analyzed by PCM and TEM ISO. Results of the Phase 2 stationary air samples are provided in Appendix C and summarized in the table at the end of this section.

### *Personal Air Samples*

Personal air monitors are worn at the breathing zone (about 4 to 6 feet above ground surface). Two types of personal air samples were collected during the disturbance activity. A "full period" personal air sample was collected from the beginning of the disturbance activity until the end of the disturbance activity. The full period sample represents the average exposure during the disturbance activity. Several "excursion" personal air samples were collected at shorter intervals within the disturbance activity when it was suspected that the highest air concentrations might be present.

Phase 2 personal air samples were collected in accordance with EPA-LIBBY-01, *SOP for the Sampling of Asbestos Fibers in Air, Revision 1* and analyzed by PCM and TEM ISO. Results of the Phase 2 personal air samples are provided in Appendix C and summarized in the table at the end of this section.

**Phase 2 Outdoor Air Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency: Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
|---|---|---|---|---|---|---|
| Pre-Activity Ambient | TEM ISO | 5 | 5 | 0 | - | - |
| | PCM | - | - | - | - | - |
| Personal Outdoor air Near Disturbed Soil | TEM ISO | 15 | 8 | 7 | 1 – 40 | 0.00799 – 0.17253 s/cc |
| | PCM | 6 | 4 | 2 | - | 0.227 - 0.268 f/cc |
| Stationary Outdoor air Near Disturbed Soil | TEM ISO | 47 | 41 | 6 | 1 – 3 | 0.00279 – 0.04017 s/cc |
| | PCM | 44 | 35 | 9 | - | 0.002 – 0.032 f/cc |
| Post-Activity Ambient | TEM ISO | 4 | 4 | 0 | - | - |
| | PCM | - | - | - | - | - |

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; PCM – phase contrast microscopy; N/A – not applicable; LA – Libby Amphibole

| Phase 2 Indoor Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | |
| Sample Type | Analytical Method | Number of Analyses | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Pre-Activity Ambient | TEM ISO | 91 | 81 | 10 | 1 – 3 | 0.00117 – 0.28950 s/cc |
| | PCM | 44 | 26 | 18 | - | 0.002 – 0.364 f/cc |
| Personal Scenario | TEM ISO | 442 | 344 | 98 | 1 – 30 | 0.00008 – 7.1358 s/cc |
| | PCM | 287 | 58 | 239 | - | 0.001 – 3.658 f/cc |
| Scenario Stationary | TEM ISO | 181 | 123 | 58 | 1 – 61 | 0.00009 – 2.4043 s/cc |
| | PCM | 102 | 24 | 78 | - | 0.002 – 1.129 f/cc |
| Post-Activity Ambient | TEM ISO | 137 | 131 | 6 | 1 – 3 | 0.00132 – 0.00523 s/cc |
| | PCM | 72 | 49 | 23 | - | 0.002 – 0.045 f/cc |

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; PCM – phase contrast microscopy; N/A – not applicable; LA – Libby Amphibole

***Real-Time Aerosol Monitors***

Airborne dust levels were measured using a real-time aerosol monitor (RAM) in accord EPA-LIBBY-03, *Site-specific SOP for Real-time Aerosol Monitoring*. Two types of measurements were obtained from the RAMs. First, continuous measurements of airborne dust levels (milligram/cubic meter) were acquired at 1-second intervals prior to the activity, during the activity, and at one or more times following the activity. These measures of airborne dust are referred to as RAM dust levels in this report. Second, filters placed within the RAM were analyzed for asbestos in the same manner as personal and stationary filters. The concentrations of asbestos in air derived from RAM filters will be referred to as HazDust asbestos concentrations in this report. Due to the variability in air flow rates through HazDust filters, confidence in estimates of asbestos concentrations in air is low for HazDust samples compared to the asbestos concentrations from stationary and personal air monitors. Because of this, the Phase 2 data summary used HazDust asbestos concentrations only in an evaluation of the correlation between dust and LA levels in air, and was not used to estimate human exposure or risk.

## 2.3.2 Soil

As part of the Phase 1 investigation, two surface soil samples had been collected from the garden selected for rototilling. Therefore, no additional soil samples were collected as part of the Phase 2 study. The soil results from the Phase 1 samples were non-detect and <1 percent by PLM-9002.

### 2.3.3 Dust

Dust samples were collected on 0.45 μm pore mixed cellulose ester (MCE) filters using a microvacuum method, similar to that detailed in ASTM 5755-95 (ASTM 1995), as modified for this project (EPA 2001b). Dust samples were collected at most of the residences in which routine and active cleaning activities (Scenarios 1 and 2) were investigated. Dust samples were also collected before and after carpet removal activities (Scenario 3C). Surficial dust samples were composite samples collected from two to four different indoor locations (each location area consisting of 100 square centimeters [$cm^2$]). Dust sampling locations included both surfaces where dust may settle out (e.g., window sills, shelves), as well as floors (e.g., entryways, living areas). If cleaning activities resulted in the generation of a visible pile of dust or dirt, a sample of this material was also collected using the microvacuum technique. These samples are referred to as "dust pile" samples. Because neither the total area swept nor the total dust mass generated was recorded for these dust pile samples, it is not possible to use the results to calculate either an asbestos loading (structures per square centimeter [$s/cm^2$]) or a concentration (structures per gram) for these samples. Therefore, samples identified as dust piles were not evaluated as part of the Phase 2 investigation conclusions.

Dust samples were analyzed using TEM ISO, modified for site-specific purposes to require recording of structures shorter than 0.5 μm and also structures with an aspect ratio less than 5:1. One dust sample was analyzed by TEM AHERA. Refer to Appendix C for additional information on individual sample details and analytical results.

A total of 65 dust samples were analyzed for the Phase 2 investigation. The one sample analyzed by TEM AHERA was non-detect for LA.

Of the 64 samples analyzed by TEM ISO:

- 36 were non-detect for LA
- 6 were collected from swept piles of dust; LA concentrations ranged from 1,698 to 29,850 $s/cm^2$
- The remaining 22 samples had LA concentrations ranging from 20 to 32,268 $s/cm^2$

### 2.3.4 Bulk Materials

A total of four bulk samples were analyzed for the Phase 2 investigation. These samples characterized the dust generated during simulated remodeling activities and were analyzed by PLM-9002. Two of the four samples were non-detect for LA, while the remaining two samples were <1 percent LA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.3.5 Vermiculite Insulation

If vermiculite insulation samples were not previously collected as part of the Phase 1, samples were collected as part of the Phase 2 study. In most instances, the insulation was collected from several locations at different depths in order to obtain a representative sample of the insulation. All insulation samples were collected and analyzed in accordance with PLM-9002.

A total of eight insulation samples were collected during the Phase 2 investigation from two properties. Of the eight samples collected, one was non-detect for LA and the remaining seven were <1 percent for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

## 2.4 Contaminant Screening Study

As mentioned above, the Phase 1 investigation demonstrated the random distribution of LA-contaminated materials throughout the Libby valley, and the CSS was designed to systematically screen approximately 4,000 properties. The CSS combined visual inspections, verbal interviews, and outdoor soil sampling to screen for the presence of potential LA source materials in areas where exposure was most likely to occur.

CSS investigations have been conducted at properties at OU4 since 2002. The 2002 CSS was initially designed in 2002 and slightly modified in 2003.

***2002 Study Design***

The 2002 CSS field activities were performed in accordance with the *CSS SAP* (CDM 2002a). Specifics on sample collection procedures and SOPs are provided in this section. The objective of the CSS investigation was to determine if contamination is present in high traffic areas on individual residential, commercial, and industrial properties. Property-specific contamination history and locations of visible vermiculite were recorded on *Information Field Forms* (IFFs). The data collected was used to determine the magnitude of the problem by identifying how many properties require remediation, may require remediation (i.e., pending), or do not require remediation.

***2003 Study Design***

The 2003 CSS and RI were slightly modified from the 2002 CSS field effort. The significant difference between the investigations is that, based on preliminary findings from the 2002 CSS, the 2003 field activities were enhanced to include intrusive techniques for attic inspections, inspection of building materials for vermiculite, indoor dust sampling, and soil sampling in large use areas that were purposely excluded from the 2002 CSS program. Additional details of the 2003 CSS program are included in the *Contaminant Screening Study, Final Technical Memorandum*, (CDM 2006b) which is provided in Appendix A.

The 2003 field activities were performed in accordance with the *Final Sampling and Analysis Plan, Remedial Investigation Contaminant Screening Study, Revision 1* (hereafter referred to as the *CSS SAP, Revision 1*[CDM 2003a]) and *Final Sampling and Analysis Plan, Remedial Investigation* (CDM 2003b). Specifics on sample collection procedures and SOPs are listed below, and copies of both documents are provided in Appendix A.

## 2.4.1 Soil

2002 CSS soil samples were collected in accordance with CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection, Revision 1*. In general, two to five 5-point (fewer if conditions limited) composite soil samples were collected from each property. Each composite sample characterized areas up to 5,500 square feet ($ft^2$); samples were collected from 0 to 1 inch bgs in yards and 0 to 6 inches bgs for driveways, landscaped areas, gardens, fill areas, etc. Because EPA initially theorized that identification of vermiculite in soil was an indicator of presence of LA at levels of concern, samples were intentionally collected from areas where vermiculite was not observed. During the CSS investigation, there was no formalized approach to inspect or quantify vermiculite in soil.

Similar to the 2002 CSS field activities, 2003 CSS soil samples were collected in accordance with CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection, Revision 1*. The primary difference between the 2002 and 2003 CSS soil sample collection procedure was that for the 2003 CSS effort, only specific use areas (SUAs) (e.g., flowerbeds, gardens) were not sampled if vermiculite was observed. Yards and driveways were sampled regardless of the presence of vermiculite. Similar to the 2002 CSS investigation, there was no formalized approach to inspect or quantify vermiculite in soil.

Since the beginning of the CSS in 2002, a total of 12,943 surface soil samples and 20 subsurface soil samples were collected. These samples were analyzed by various methods resulting in 21,517 analytical results for the 12,963 soil samples collected. These samples were collected from 3,211 properties (Figure 2-1 and Figure 2-2). Below is a summary of the results by analytical method and LA detection frequency:

**CSS Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
|---|---|---|---|---|---|---|---|
| Surface | PLM-9002 | 403 | 377 | - | 26 | - | - |
| | PLM-VE | 12,698 | 11,652 | 945 | - | 76 | 25 |
| | PLM-Grav | 8,306 | 8,233 | 59 | - | 5 | 9 |
| | EPA-600 | 84 | 81 | 3 | - | - | - |
| Subsurface | PLM-9002 | 5 | 4 | - | 1 | - | - |
| | PLM-VE | 18 | 16 | 2 | - | - | - |
| | PLM-Grav | 3 | 3 | - | - | - | - |

Notes: ND – non-detect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

As the table above shows, the majority of sample results (20,366 or 94.65 percent) were non-detect for LA. The 1,151 LA detections were collected from 688 individual properties. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.4.2 Dust

Microvacuum dust samples were not collected during the 2002 CSS field effort. During the 2003 CSS field effort, field teams began collecting dust samples from properties if LA sources were present and/or if secondary indicators (e.g., former mine worker) were present. The 2003 CSS dust samples were collected in accordance with ASTM D5755 with modifications as described in the *Sampling and Analysis Plan for Indoor Dust* (EPA 2003b) which is provided in Appendix A. This SAP specifies that two dust samples would be collected from the high traffic and horizontal surfaces of each floor, and three 100 $cm^2$ sample areas would be included on each cassette.

As specified in the *Sampling and Analysis Plan for Indoor Dust* (EPA 2003b), microvacuum dust samples associated with the 2003 RI were analyzed in accordance with TEM AHERA or TEM ISO. A target analytical sensitivity of 500 per square centimeter ($cm^{-2}$) was established for these samples. Samples with analytical sensitivities greater than 1,000 $cm^{-2}$ were used for removal decisions only on a case-by-case basis.

Since the beginning of CSS dust sample collection in 2003, a total of 3,156 dust samples were collected from 807 different properties. Of these samples 1,930 have been analyzed (Figure 2-3) from dust samples collected at 536 properties. The remaining samples were archived indefinitely when the analytical soil results for each property were reviewed and it was assumed properties without soil contamination would be less likely to have contaminated dust samples. Below is a summary of the results by analytical method and detection frequency:

- A total of 1,985 samples were analyzed by TEM AHERA, of these samples
  - 1,815 samples were non-detect for LA
  - 170 samples had detectable levels of LA ranging from 44 to 264,285 s/$cm^2$
- A total of 25 samples were analyzed by TEM ISO, one sample detected LA at a concentration of 292 s/$cm^2$ while the remaining samples were non-detect for LA.

Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.4.3 Bulk Materials

One bulk material was collected as part of the CSS from chinking around a basement chimney. This sample was analyzed by PLM-9002 and was non-detect for LA. Refer to Appendix C for additional information of sample details and the analytical result.

## 2.5 Contamination Assessments at Specialty Properties

poor transition [illegible]

The inspection of several properties varied from the traditional process due to the unique history of contamination or special interest as a public area. The following section describes contamination assessments performed through 2009 at unique or complex properties within OU4, which are illustrated on Figure 2-17.

### 2.5.1 Kootenai Bluffs Subdivision

The Kootenai Bluffs Subdivision is located on the west side of the Kootenai River, directly across the river from the former Screening Plant (Figure 2-17). When the vermiculite mine was in operation, a portion of the property was used by Grace as a conveyor unloading station. The sorted vermiculite was received from the Screening Plant via a conveyor constructed across the Kootenai River and loaded onto trucks or railroad cars for distribution to numerous expansion plants throughout the United States. The remainder of the bluffs property historically consisted of undeveloped land that does not appear to have been associated with previous commercial operations of the vermiculite mine. Due to the property's affiliation with the former Screening Plant, the Kootenai Bluffs Subdivision was formerly classified as OU2. The subdivision consists of 12 lots: Lots 1 and 2 are privately owned and have been developed; Lots 3 and 4 are vacant and privately owned; KDC (a subsidiary of Grace) owns the remaining eight lots.

Characterization of the Kootenai Bluffs Subdivision began in December 1999, and continued into July 2001. A total of 197 soil samples (grab and 5-point composite) were collected from the conveyor unloading station, several stockpiles, test pits, and accessible land that was not heavily wooded. Eight samples were collected from the subsurface soils (greater than 3 inches bgs), while the remaining samples were collected from the surface soil. Samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b).

Results from the soil samples analyzed by PLM-9002 indicate that 104 samples contained detectable concentrations of LA ranging from <1 to 10 percent. The results of the remaining soil samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results. The table presented at the end of this section summarizes the soil sample results by analytical method.

In April 2006, prior to construction of the first residential house, six soil samples were collected from the area surrounding the proposed building site. Each surface soil sample was a 5-point composite and was collected, handled, and analyzed in accordance with the *CSS SAP, Revision 1*, (CDM 2003a). Results from the soil samples, analyzed using two techniques for LA (PLM-VE and PLM-Grav), indicate that two of these samples detected trace concentrations of LA and the remaining samples were non-detect. A detailed summary of sample collection events through 2006, as well as the location and results for the individual samples collected during these investigations are presented in the *Final Data Summary Report for Operable Unit 2:*

*Former Screening Plant and Surrounding Area* (CDM 2008b) which is provided in Appendix A.

In 2009, Lots 1-4 of the subdivision were recharacterized utilizing current protocols for visual vermiculite inspection in soil and soil sample collection. In addition, an indoor inspection was completed within each building present within the investigation limits. Samples were collected, handled, and analyzed in accordance with *Wise Property and Kootenai Bluffs Subdivision Technical Sampling Memorandum* (CDM 2009b) which is provided in Appendix A.

A total of 53 soil samples were collected from Lots 1-4. A low amount of vermiculite was observed at three locations within Lot 1, and at three locations within Lot 3. Vermiculite was not observed within the interior of any inspected buildings. The analytical results for all samples collected in 2009 were non-detect for LA by PLM-VE and PLM-Grav. A detailed summary of this sample collection event, as well as the location and results for the individual samples collected during this investigation are presented in the *Wise Property and Kootenai Bluffs Subdivision Summary Memorandum* (CDM 2009c) which is provided in Appendix A.

**Kootenai Bluffs Subdivision Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 189 | 90 | - | 79 | - | 20 |
| | PLM-VE | 59 | 57 | 2 | - | - | - |
| | PLM-Grav | 51 | 51 | - | - | - | - |
| Subsurface | PLM-9002 | 8 | 3 | - | 1 | - | 4 |

Notes: ND – non-detect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

The removal action which addressed the soil contamination at the Kootenai Bluffs Subdivision is discussed in Section 2.21.4.

## 2.5.2 Kootenai Valley Head Start

Located at 263 Indian Head Road (Figure 2-17), Kootenai Valley Head Start is the location of the former Plummer Elementary School and was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b).

### 2.5.2.1 Air

During the initial assessment in January 2000, four indoor air samples and three outdoor ambient air samples were collected and analyzed by TEM ISO.

In April 2000, background outdoor ambient air monitoring began and continued through November of that year. Twenty stationary air samples were collected during that time period and were also analyzed by TEM ISO.

The analytical result of one stationary air sample collected in August 2000 detected LA at a concentration of 0.00093 s/cm², while all other air samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.2.2 Dust

Additionally in January 2000, four dust samples were collected from the following locations within the school building: gym, janitor's closet, and window sills of two classrooms. All samples were analyzed by TEM ISO. Analytical results of all dust samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.2.3 Soil

In 2001, four sample collection events and outdoor inspections were conducted, and 26 grab and 27 composite surface soil samples were collected from the yard and play areas surrounding the school. The composited soil samples ranged from 2- to 5-point composites and were collected from 0 to 4 inches bgs. The remaining 26 samples were grab samples collected from depths ranging from 0 to 20 inches bgs.

What does this mean
If I want to know where
the individual sample
locations were?

In 2002, three additional 3-point composite surface soil samples, and one grab subsurface soil sample were collected. The analytical result of the subsurface sample, which contained suspected mine waste, was 7 percent LA by PLM-9002 while the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

old ice rink?
or parcel area
Addressed?

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Below is a summary of the results by analytical method and LA detection frequency for the 57 total soil samples:

| Kootenai Valley Head Start Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 56 | 49 | - | 5 | - | 2 |
| | PLM-VE | 44 | 42 | 2 | - | - | - |
| | PLM-Grav | 36 | 34 | - | - | - | 2 |
| Subsurface | PLM-9002 | 1 | - | - | - | - | 1 |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

The removal action which addressed the soil contamination at Kootenai Valley Head Start is discussed in Section 2.21.2.

### 2.5.3 Libby Elementary School

Located at 700 Idaho Avenue (Figure 2-17) and formerly known as Asa Wood Elementary School, Libby Elementary School was first investigated in January 2000 as part of the Phase 1 investigation. An inspection of the building was completed, but vermiculite insulation was not observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b).

#### 2.5.3.1 Air

During the initial assessment, six indoor air samples were collected from locations throughout the school. Analytical results for all samples were non-detect for LA by TEM ISO. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.3.2 Dust

Additionally in January 2000, six dust samples were collected from the following locations: boiler room, stage, and window sills of the stage, front office, music room, and one classroom. Analytical results for all dust samples were non-detect for LA by TEM ISO. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.3.3 Soil

In March 2001, four grab subsurface and nine grab surface soil samples were collected from the play areas surrounding the school. The surface samples were collected from depths ranging from 0 to 30 inches bgs, and the subsurface samples were collected from depths ranging from 6 to 18 inches bgs. These soil samples were archived and have not been analyzed.

In June 2001, an additional 25 surface soil samples (grab and composite) and three grab subsurface soil samples were collected from the yard and play areas surrounding the school. The 5-point composite soil samples were collected from 0 to 4 inches bgs, and the grab samples ranged in depths from 0 to 18 inches bgs. Refer to Appendix C for additional information on individual sample details and analytical results.

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Below is a summary of the results by analytical method and LA detection frequency for the 28 total soil samples:

| Libby Elementary School Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 25 | 23 | - | 2 | - | - |
| | PLM-VE | 23 | 21 | 2 | - | - | - |
| | PLM-Grav | 22 | 22 | - | - | - | - |
| Subsurface | PLM-9002 | 3 | 3 | - | - | - | - |
| | PLM-VE | 3 | 2 | 1 | - | - | - |
| | PLM-Grav | 2 | 2 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

## 2.5.4 Libby Middle School

Located at 101 Ski Road (Figure 2-17), Libby Middle School was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b).

### 2.5.4.1 Air

During the initial inspection in January 2000, eight indoor stationary air samples were collected throughout the school. Analytical results of all samples were non-detect for LA by TEM ISO.

In September 2001, an additional air sample was collected from the storage shed on the baseball field. The analytical result for this air sample was non-detect for LA by TEM AHERA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.5.4.2 Dust

Additionally in January 2000, seven dust samples were collected from the following locations within the school building: south end of auditorium, entrance to gym, and window sills of five classrooms. All samples were analyzed by TEM ISO. Analytical results of all dust samples were non-detect for LA.

In March 2009, two dust samples were collected from the high jump mat on the athletic field after it was determined that the mat originated from Libby High School. As discussed in Section 2.21.1, the athletic equipment at Libby High School was disposed of in conjunction with the track removal in 2001. The analytical result for one dust sample had a detectable concentration of 786 s/cm$^2$ LA, while the other sample was non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the dust contamination at Libby Middle School is discussed in Section 2.21.3.

### 2.5.4.3 Soil

In 2001, outdoor inspections focused on the track and an additional three feet on the inner and outer sides of the track, but also sampled the play areas and yard surrounding the school. Eight grab subsurface soil samples and 159 surface soil samples (grab and composite) were collected over four different sampling events. Soil samples were a combination of 2- to 5-point composite samples and grab samples collected at various depths. Refer to Appendix C for additional information on individual sample details and analytical results.

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. The table below summarizes the results by analytical method and LA detection frequency for the 167 total soil samples.

Have we cleaned this up?

| Libby Middle School Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 207 | 181 | - | 18 | - | 8 |
| | PLM-VE | 126 | 117 | 9 | - | - | - |
| | PLM-Grav | 103 | 103 | - | - | - | - |
| Subsurface | PLM-9002 | 8 | - | - | 3 | - | 5 |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

The removal action which addressed the soil contamination at Libby Middle School is discussed in Section 2.21.3.

## 2.5.5 Libby High School

Located at 150 Education Way (Figure 2-17), Libby High School was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust, soil, and bulk characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b).

### 2.5.5.1 Air

During the initial inspection in January 2000, ten indoor stationary air samples were collected throughout the school. Analytical results of all samples were non-detect for LA by TEM ISO.

In June 2001, two additional air samples were collected from the east and west equipment sheds. Analytical results for both air samples were non-detect by PCM. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.5.2 Dust

Additionally in January 2000, ten dust samples were collected from the following locations within the school building: boiler room and window sills of the main entry hallway, hallway to the gym, drafting room, and six classrooms. All samples were analyzed by TEM ISO. LA was detected in the dust sample collected from the boiler room at a concentration of 322 s/cm² while the remaining dust samples were non-detect for LA.

Eight additional dust samples were collected from the outbuildings surrounding the track during the 2001 removal action, and analyzed by TEM ISO. The areas sampled include the football field storage building, snack bar, press box, visitors' coach box, storage garage, and bleachers. Analytical results for the samples collected from the home side bleachers and football field east storage building were non-detect for LA while the remaining samples had detectable levels of LA ranging from 1,132 to 42,459 s/cm². Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the dust contamination at Libby High School is discussed in Section 2.21.1.

#### 2.5.5.3 Soil

In 2001, outdoor inspections focused on the track and an additional three feet on the inner and outer sides of the track, but also sampled the yard surrounding the school. From March through August, 19 subsurface and 217 surface soil samples were collected. Soil samples were a combination of 2- to 5-point composite samples and grab samples collected at various depths. Refer to Appendix C for additional information on individual sample details and analytical results.

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. The table below summarizes the results by analytical method and LA detection frequency for the 236 total soil samples.

Addressed ABS sampling yield tr levels in 2009

**Libby High School Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 223 | 178 | - | 41 | - | 4 |
| | PLM-VE | 151 | 132 | 18 | - | 1 | - |
| | PLM-Grav | 78 | 77 | 1 | - | - | - |
| Subsurface | PLM-9002 | 18 | 8 | - | 6 | - | 4 |
| | PLM-VE | 8 | 8 | - | - | - | - |
| | PLM-Grav | 5 | 5 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

The removal action which addressed the soil contamination at Libby High School is discussed in Section 2.21.1.

#### 2.5.5.4 Bulk Materials

In October 2001, concern was raised regarding the dryers used to launder athletic uniforms at the school. The dryers were reportedly once owned by Grace. Four bulk samples were collected of the lint in the lint traps. All samples were non-detect for LA by PLM-9002. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.5.6 Libby School District Administration Building

Located at 724 Louisiana Avenue (Figure 2-17), the Libby School District Administration Building was first investigated in January 2000 as part of the Phase 1 investigation. An inspection of the building was completed, and vermiculite insulation was observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b) and *CSS SAP, Revision 1* (CDM 2003a).

#### 2.5.6.1 Air

During the initial assessment, five indoor air samples were collected from locations throughout the school. The analytical result of the sample collected from the second floor hallway detected LA at a concentration of 0.00081 s/cm$^2$, while all other air samples were non-detect for LA.

In September 2003, two additional air samples were collected from the first and second floor of the school. Analytical results for both samples had fiber concentrations ranging from 0.002 to 0.003 fibers per cubic centimeter (f/cc) by PCM. PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.6.2 Dust

Additionally in January 2000, five dust samples were collected from the windowsills of the following areas: board of trustee's room, business office, community interagency office, south end of hallway, and electrical closet. Analytical results for all samples were non-detect for LA by TEM ISO.

In June 2001, two additional dust samples were collected from the old and new sections of the school. Analytical results for both samples were non-detect for LA by TEM ISO. Refer to Appendix C for additional information on individual sample details and analytical results.

#### 2.5.6.3 Soil

In 2001, two grab subsurface and eight grab surface soil samples were collected from the play area and yard surrounding the school. In April 2003, four additional surface soil samples (5-point composite) were collected from the driveway and side yard. The composite soil samples ranged in depths from 0 to 6 inches bgs, and the grab samples ranged in depths from 0 to 16 inches bgs. These samples were analyzed by multiple PLM methods and four of the samples collected from 2001 were reanalyzed under a different sample index number. Analytical results for all samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Below is a summary of the results by analytical method and LA detection frequency for the 14 total soil samples:

| Libby Administration Building Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 12 | 12 | - | - | - | - |
| | PLM-VE | 12 | 12 | - | - | - | - |
| | PLM-Grav | 6 | 6 | - | - | - | - |
| Subsurface | PLM-9002 | 2 | 2 | - | - | - | - |
| | PLM-VE | 2 | 2 | - | - | - | - |
| | PLM-Grav | 1 | 1 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

### 2.5.6.4 Vermiculite Insulation

In June 2001, four vermiculite insulation samples were collected of vermiculite insulation observed in the attic of the old portion of the building. All insulation was identified as vermiculite; however, analytical results of three samples were non-detect for LA by PLM-9002 and one sample had a concentration of <1 percent LA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.5.6.5 Bulk Materials

Also in June 2001, three bulk material samples were collected from remodeling activities on the second floor. Analytical results of two samples were non-detect for LA by PLM-9002 and one sample had a concentration of <1 percent LA. Refer to Appendix C for additional information on individual sample details and analytical results.

Based on the investigation findings at the Libby Administration Building, additional characterization activities (i.e., PDI) were conducted at the property. This additional work is described in Section 2.19.1.

The removal action which addressed the indoor contamination at Libby Administration Building is discussed in Section 2.21.6.

## 2.5.7 McGrade Center

Located at 899 Farm to Market Road (Figure 2-17), the McGrade Center is the location of the former McGrade Elementary School and was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, EPA 2000b).

### 2.5.7.1 Air

During the initial assessment in January 2000, four indoor air samples and two outdoor ambient air samples were collected and analyzed by TEM ISO.

In April 2000, background outdoor ambient air monitoring began and continued through November of that year. Twenty-five stationary air samples were collected during that time period and were also analyzed by TEM ISO.

Analytical results for four of the outdoor ambient air samples had detectable levels of LA ranging from 0.00010 to 0.00168 s/cm$^2$ while the remaining samples were non-detect for LA by TEM ISO. The analytical result for indoor air sample was not available in the project database at the time of this report. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.5.7.2 Dust

Additionally in January 2000, four dust samples were collected from the following locations: janitor's room, gym, and window sills of rooms 12 and 8. Analytical results for all samples were non-detect for LA by TEM ISO. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.5.7.3 Soil

In March 2001, eight grab surface soil samples and six grab subsurface soil samples were collected from the yard and play areas surrounding the school. The surface samples were collected from depths ranging from 0 to 24 inches bgs, and the subsurface samples were collected from depths ranging from 6 to 24 inches bgs. These soil samples were archived and have not been analyzed.

Beginning in June 2001, three sample collections events and outdoor inspections were conducted, and 20 grab and 19 composite surface soil samples were collected from the yard and play areas surrounding the school, and from the adjacent Jerry Dean Park. All samples were collected from depths ranging from 0 to 8 inches bgs. Refer to Appendix C for additional information on individual sample details and analytical results.

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Below is a summary of the results by analytical method and LA detection frequency for the 39 total soil samples:

| McGrade Center Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 39 | 38 | - | 1 | - | - |
| | PLM-VE | 30 | 29 | 1 | - | - | - |
| | PLM-Grav | 103 | 23 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

## 2.5.8 Cemetery Park Ball Fields

Located at 855 Crotteau Road (Figure 2-17), contamination at the Cemetery Park Ball Fields has been investigated during both Phase 1 and CSS. Investigations at the park began in 2002 to address suspicions of contaminated backfill on the ball fields and concerns of children being potentially exposed to LA during the baseball season.

According to an interview conducted in 2002, prior to the construction of the baseball fields, the area was undeveloped and mostly under water (i.e., a swamp). The area was backfilled in 1995 by the City of Libby. It was estimated that approximately 2 to 3 feet of riprap and 3 to 5 feet of common fill were used as backfill throughout the area. This area was then backfilled with 6 to 8 inches of topsoil and the parking lots were backfilled with gravel.

Source of riprap?? Syenite from mine??

Visual inspections were performed to determine if vermiculite and/or LA were present in the park, but vermiculite was not observed during the soil sampling events. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 2000b), *CSS SAP* (CDM 2002a), and *Final Sampling and Analysis Plan Addendum for the Cemetery Park Ball Fields* (CDM 2002b) which are provided in Appendix A.

### 2.5.8.1 Air

In 2002, one stationary air sample was collected within the concession stand. The analytical result by PCM had a fiber concentration of 0.005 f/cc. As PCM cannot be reported as concentrations of LA, the sample was reanalyzed by TEM ISO and was non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.5.8.2 Dust

Additionally, five dust samples were collected from the Cemetery Park Ball Fields concession stand and equipment stored in the stand. Analytical results for three samples were non-detect for LA. The remaining two samples collected from the first and second levels of the concession stand detectable concentrations of LA ranging from 3,511 to 5,853 s/cm$^2$. Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the dust contamination at the Cemetery Park Ball Fields is discussed in Section 2.21.5.

#### 2.5.8.3 Soil

In May 2002, 12 surface soil samples were collected from the ball fields. An additional 8 surface soil and 12 subsurface were collected from the walkway, parking lots, ball field and wooded areas in August 2002. All samples were 5-point composites and the surface soil samples were collected from 0 to 4 inches bgs. The subsurface soil samples were collected from depths ranging from 4 to 18 inches bgs. Surface and subsurface samples were co-located but individually collected. A detailed summary of the sample collection events, as well as the location and results for the individual samples are presented in the *Final Summary Report for the Cemetery Park Ball Fields* (CDM 2005a) which is provided in Appendix A.

These samples were analyzed by multiple PLM methods and were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results. Below is a summary of the results by analytical method and LA detection frequency for the 32 total soil samples:

| McGrade Center Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 12 | 12 | - | - | - | - |
| | PLM-VE | 32 | 32 | - | - | - | - |
| | PLM-Grav | 31 | 31 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

### 2.5.9 St. John's Rehabilitation Center and Helipad Field

The St. John's Rehabilitation Center and Helipad Field is located at 308 East 2nd Street and is illustrated on Figure 2-17. Historical activities at the Helipad field include a Grace vermiculite bagging facility and subsequent City of Libby sports/recreation field. All investigation activities were conducted by CDM in accordance with the *CSS SAP, Revision 1* (CDM 2003a).

As part of the initial investigation, the rehabilitation center and two sheds were inspected to determine if vermiculite insulation or building materials were present. Vermiculite insulation was not observed in any of the three structures.

#### 2.5.9.1 Soil

Soil sampling at the property was initially conducted in June 2002. Two 5-point composite surface soil samples were collected to characterize the yard and flowerbeds surrounding the rehabilitation center. Analytical results for both samples were non-detect for LA by PLM-VE, although vermiculite was noticed in both locations during sampling.

Supplemental soil sampling was conducted in October 2004 to characterize the field north and east of the rehabilitation center surrounding the Helipad. The field was divided into grids each approximately 100 feet by 100 feet or 75 feet by 150 feet, depending on site conditions. A 5-point composite sample was collected from each grid square. In total, 15 surface soil samples were collected, at depths from 0 to 1 inch bgs.

During this sampling event, gross quantities of vermiculite were observed in the north and west corners of the field, and within the three planter boxes. Vermiculite was also observed in varying quantities within 10 of the 15 grids. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Draft Summary Report for the St. John's Lutheran Hospital Rehabilitation Center and Helipad Field* (CDM 2006c) which is provided in Appendix A.

Analytical results of seven samples had detectable levels of LA ranging from trace to <1 percent LA, while the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual samples details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 17 total soil samples:

**St. John's Rehabilitation Center and Helipad Field Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 17 | 10 | 6 | - | 1 | - |
| | PLM-Grav | 8 | 8 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

Based on the investigation findings at the Helipad, additional characterization activities (i.e., PDI) were conducted at the property. This additional work is described in Section 2.19.2 of this report.

The removal action which addressed the soil contamination at the Helipad is discussed in Section 2.21.8.

### 2.5.9.2 Air

In May 2006, St. John's Hospital began construction of a new building on the property. Two stationary air samples were collected in accordance with EPA SOP 2015: *Asbestos Sampling in Air* which is described in the *Final Draft Response Action Work Plan,* hereafter referred to as the *RAWP* (CDM 2003c) and which is provided in Appendix A. Analytical results for both samples were non-detect for LA by TEM AHERA. Refer to Appendix C for additional information on individual samples details and analytical results.

### 2.5.10 Libby Drive-In Theater

The Libby Drive-In Theater is located at 1144 U.S. Highway 2 (Figure 2-17) and consistent with other areas of OU4, vermiculite may have been used as base and/or fill material throughout the drive-in area. In September 2003, EPA conducted an investigation to determine the presence of vermiculite and/or LA at the property. All investigation activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM 2003a), and *Final Sampling and Analysis Plan Addendum for the Libby Drive-In Theater* (CDM 2002c) which are provided in Appendix A.

As part of the investigation, the ticket booth and concession stand were inspected to determine if vermiculite insulation or building materials were present. A visual inspection of both structures on the property was conducted and no vermiculite insulation was observed in either of the structures.

The property was divided into grids each approximately 125 feet by 125 feet. A 5-point composite sample was collected from each grid square. In total, 19 surface soil samples were collected, at depths from 0 to 6 inches bgs.

In addition, a visual inspection was performed during the soil sampling efforts to determine if any vermiculite was present in soils. No vermiculite was observed during the soil sampling events. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Final Summary Report for the Libby Drive-In Theater* (CDM 2005b) which is provided in Appendix A.

Analytical results of the 19 samples were non-detect for LA by PLM-VE. Refer to Appendix C for additional information on individual samples details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 19 total soil samples:

**Libby Drive-In Theater Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 19 | 19 | - | - | - | - |
| | PLM-Grav | 19 | 19 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

In the summer of 2007, a severe thunderstorm damaged the property and the drive-in was closed indefinitely.

## 2.5.11 Cabinet View Country Club

During 2004, a CSS investigation was conducted at the local golf course, Cabinet View Country Club (CVCC), located at 458 Cabinet View Country Club Road (Figure 2-17). In addition to a verbal interview, visual inspections were performed and soil and dust samples collected to determine the presence of vermiculite and/or LA throughout the golf course club house, pumphouse, greens, fairways, tee boxes, and sand traps. Field activities were completed in accordance with the *CSS SAP, Revision* 1 (CDM 2003a) and *Final Sampling and Analysis Plan Addendum for the Cabinet View Country Club* (CDM 2004a) which are provided in Appendix A.

### 2.5.11.1 Soil

A total of 90 soil samples were collected in 2004. Soil samples were either surface grab samples or 5-point composite surface or subsurface samples. Vermiculite was not observed in the club house; however, it was observed in a portion of the pumphouse attic and sifting from the walls of the original section of that building. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Final Summary Report for the Cabinet View Country Club* (CDM 2005c) which is provided in Appendix A.

In July 2008, an additional investigation soil sample was collected from a sand stockpile located and used at the golf course. The 30-point composite surface sample was collected in accordance with CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection, Revision 2.*

Analytical results of 34 samples had detectable levels of LA ranging from trace to <1 percent LA, while the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual samples details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 91 total soil samples:

Where are Calahan, Libby, Flower, Pipe & Granite Creeks?
(I just wrote about them for the CCR)

| CVCC Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 1 | 1 | - | - | - | - |
| | PLM-VE | 79 | 48 | 29 | - | 2 | - |
| | PLM-Grav | 13 | 13 | - | - | - | - |
| Subsurface | PLM-VE | 10 | 7 | 3 | - | - | - |
| | PLM-Grav | 8 | 8 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

#### 2.5.11.2 Dust

Additionally in 2004, one dust sample was collected from the pumphouse. This sample was analyzed by TEM AHERA and the analytical result was non-detect for LA.

Based on the investigation findings at the CVCC golf course, additional characterization activities (i.e., PDI) were conducted at the property. This additional work is described in Section 2.19.3 of this report.

The removal action which addressed the contamination at the CVCC is discussed in Section 2.21.13.

### 2.5.12 J. Neils Park

J. Neils Park is located north of the Kootenai River, approximately 1 mile along Highway 37 (Figure 2-17). Consistent with other areas of OU4, vermiculite may have been used as base and/or fill material throughout the J. Neils Park paths, playground areas, sport fields, parking areas and concession areas. In September 2003, EPA conducted an investigation to determine the presence of vermiculite and/or LA at the property. All investigation activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM 2003a), and *Final Sampling and Analysis Plan Addendum for J. Neils Park and State Highway 37* (CDM 2003d) which are provided in Appendix A.

Initially, a visual inspection of J. Neils Park was performed in August 2002 to determine if any vermiculite was present. All structures were inspected and vermiculite insulation was not observed in any of the structures on the property. Small amounts of vermiculite were observed on two ball fields, between the bathrooms and playground, and at the entrance to the horse arena.

Soil sampling at J. Neils Park was conducted in two separate events: September 2003, and March 2005. Initially, the park was divided into four subareas including the pathways (i.e., horse path, walking path, and access road), the former airfield area, the forested area, and the areas where visible vermiculite was identified during the initial visual inspection. There was no evidence to indicate that the forested area contained LA; therefore, only the cleared area was sampled. In total, 67 composite surface soil samples were collected during the September 2003 investigation, No vermiculite was observed during the sampling event.

Following the sampling event in September 2003, the City of Libby contacted EPA regarding maintenance they wanted to perform on the ball fields before the spring baseball season. Therefore, surface soil samples were collected from the infield portion of each ball field to further define the nature and extent of contamination. Each infield was split into three sections and a 5-point composite sample from 0-1 inches was collected from each area. A total of 12 composite surface samples were collected from the four ball fields.

Analytical results of five soil samples have detectable levels of LA ranging from trace to <1 percent LA, while the remaining samples were non-detect for LA by PLM-VE. A detailed summary of the sample collection events, as well as the locations and results for the individual samples are presented in the *Final Summary Report for the J. Neils Park and State Highway 37 Investigations, Revision 1* (CDM 2005d) which is provided in Appendix A. Refer to Appendix C for additional information on individual sample details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 79 total soil samples:

**J. Neils Park Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 79 | 74 | 4 | - | 1 | - |
| | PLM-Grav | 78 | 78 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

The removal action which addressed the soil contamination at J. Neils Park is discussed in Section 2.21.9.

### 2.5.13 City of Libby Alleys

In September 2002, in conjunction with CSS activities at 101 Mineral Avenue, a surface soil sample was collected from the alley adjacent to the property (Alley #31). In 2003, a full CSS investigation involving a verbal interview, visual inspection for vermiculite, and surface soil and outdoor ambient air sampling was conducted at Libby's alleys. Objectives of this investigation were to: 1) determine the presence of vermiculite and/or LA in the alleys; and 2) to determine the presence of LA in airborne dust disturbed by normal alley traffic. Activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM 2003a), and *Final Sampling and Analysis Plan Addendum for the City of Libby Alley Investigation* (CDM 2003e) which are provided in Appendix A. Interview, inspection, and soil sampling activities took place in October 2003; air sampling was conducted in August 2005. All activities were summarized in the *Final Summary Report for the City of Libby Alley Investigation* (CDM 2005e) which is provided in Appendix A.

As reported in the alley investigation summary report, vermiculite was observed in 25 of Libby's 128 alleys, and for all 25 alleys, a property adjacent to the alley also contained visible vermiculite. That is, the vermiculite appeared to have migrated into the alley from an adjacent property. It is not suspected that vermiculite was used as a base material or surface material for alley construction. The locations of visible vermiculite and descriptions of each alley type are shown on Figure 2-18.

### 2.5.13.1 Soil

In total, 96 composite surface soil samples were collected at the City of Libby alleys. The composited soil samples ranged from 2 to 12-point composites and were collected from 0 to 6 inches bgs. These samples were analyzed by multiple PLM methods and two samples had detectable concentrations of LA ranging from trace to <1 percent LA while the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 96 total soil samples:

**City of Libby Alley Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 1 | - | - | 1 | - | - |
| | PLM-VE | 95 | 94 | 1 | - | - | - |
| | PLM-Grav | 95 | 95 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

### 2.5.13.2 Air

In 2005, 30 outdoor stationary air samples were collected from eight randomly selected alleys (refer to the summary report for exact locations). Analytical results for one sample collected at each of three separate alleys had detectable concentrations of LA ranging from 0.00095 to 0.00100 s/cm$^2$ while the remaining samples were non-detect for LA by TEM AHERA.

| City of Libby Alley Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Outdoor Ambient | TEM AHERA | 30 | 27 | 3 | 0 – 1 | 0.00095 – 0.00100 s/cc |

Notes: LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; AHERA – Asbestos Hazard Emergency Response Act; s/cc – structures per cubic centimeter

Vermiculite and LA contamination in Libby alleys is currently being addressed on a case-by-case basis during removals at adjacent properties. The removal actions which addressed the soil contamination to date are discussed in Section 2.21.10.

## 2.5.14 Johnston Acres Subdivision

In 2004, the need to investigate the Johnston Acres subdivision arose when EPA learned that the City of Libby was moving forward on a civil works project to replace aging water lines and transfer residential properties from septic to city sewer within the subdivision. Information gathered during the CSS at properties within the subdivision, indicated that waste rock from the mine may have been brought in and used as fill material. The location of the Johnston Acres subdivision is depicted on Figure 2-17.

EPA decided to conduct an investigation of the subdivision to ensure that the city contractor was working in safe conditions and to prevent the potential spread of contamination. Based on this information, a sampling plan was established to assess whether waste rock material existed within the Johnston Acres subdivision, and if so, where the waste rock material was located. All investigation activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM 2003a), and *Johnston Acres Field Investigation Memorandum* (CDM 2005f) which are provided in Appendix A.

### 2.5.14.1 Soil

In January 2005, the investigation targeted the City's proposed areas of excavation and included yard samples adjacent to the street as well as street samples from the right-of-way. Direct Push Technology was used to advance 44 borings to a minimum of 6 feet bgs and a maximum of 15 feet bgs (depending on the depth of native soil). Cores were visually inspected for waste rock material and vermiculite.

In addition, a total of 45 grab soil samples were collected from the borings to determine the nature and extent of LA. The majority of samples (26) were collected from the subsurface, while the remaining 19 samples were collected from the surface soils. Vermiculite was observed in the topsoil at 2 locations, but not at depth. Vermiculite was not observed in any other surface or subsurface locations during sampling. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Draft Summary Report for the Johnston Acres Field Investigation* (CDM 2005g) which is provided in Appendix A.

Analytical results of four soil samples revealed trace LA by PLM-VE, while the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Below is a summary of the results by analytical method and LA detection frequency for the 45 total soil samples:

| Johnston Acres Subdivision Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 16 | 14 | 2 | - | - | - |
| | PLM-Grav | 13 | 13 | - | - | - | - |
| Subsurface | PLM-VE | 34 | 31 | 3 | - | - | - |
| | PLM-Grav | 27 | 27 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

### 2.5.14.2 Air

As the water line installation continued throughout 2005, 14 stationary air samples were collected to monitor for LA emissions. These samples were collected in accordance with EPA SOP 2015; *Asbestos Sampling in Air* which is described in the *RAWP* (CDM 2003c).

A total of 14 stationary air samples were collected at 11 properties in the Johnston Acres Subdivision and were analyzed by TEM AHERA. Analytical results for two samples had detectable levels of LA ranging from 0.000407 to 0.000485 structures per cubic centimeter (s/cc) while the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the contamination at the Johnston Acres Subdivision is discussed in Section 2.21.7.

## 2.5.15 Former Concrete Plant

The former concrete plant property encompasses approximately 24 acres and includes two residential units, a large three bay open structure, a concrete scrap pile, a large concrete foundation, abandoned concrete equipment, two underground storage tanks, and several abandoned wooden structures. Other structures on the property have collapsed. The property consists of three addresses which are shown on Figure 2-17: 1080 U.S. Highway 2, 31425 U.S. Highway 2, and 31445 U.S. Highway 2.

Source of limestone for concrete? Chrysotile present?

In 2002, each of the residential units was investigated during the CSS in accordance with the *CSS SAP* (CDM 2002a). Three surface soil samples were collected from the yard and driveways. Each sample was a composite ranging from 2 to 5 points and was collected from depths ranging from 0 to 6 inches bgs. Vermiculite was observed in the yard, flowerbeds, and garden and vermiculite insulation was observed in the attics of both residences.

In 2003, the entire property was divided into 150-foot by 150-foot grids and surface soil samples were collected from each of the 42 grids. The soil samples were 5-point composites collected from 0 to 6 inches bgs. Vermiculite was observed in concrete in the concrete scrap pile, but was not observed in any other areas. The investigation of the former concrete plant was conducted in accordance with the *CSS SAP, Revision 1* (CDM 2003a), and *Draft Sampling and Analysis Plan Addendum for the Former Concrete Plant Investigation* (CDM 2005h) which are provided in Appendix A.

Analytical results of four soil samples had detectable levels of LA ranging from trace to <1 percent LA, while the remaining samples were non-detect for LA by PLM-VE. Refer to Appendix C for additional information on individual sample details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 45 total soil samples:

| Former Concrete Plant Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 46 | 42 | 2 | - | 2 | - |
| | PLM-Grav | 20 | 20 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

Based on the investigation findings at the former concrete plant, additional characterization activities (i.e., PDI) were conducted at the property. This additional work is described in Section 2.19.4 of this report.

The removal action which addressed the contamination at the former Concrete Plant is discussed in Section 2.21.12.

### 2.5.16 Former Landfill

Located at 255 County Shop Road (Figure 2-17), the City of Libby Former Landfill encompasses approximately 5 acres and is currently undeveloped, with portions of overgrown vegetation. The northern portion of the property remains heavily wooded. The property operated as a dump and burn landfill prior to 1970. The majority of the operations were confined to the southwest section of the property. Waste accepted during operation consisted mainly of municipal waste. Additional wastes disposed of at the landfill included snow removal debris and old vehicles. Old septic trenches are present in the northern section of the property. The landfill was unregulated during operation and the exact nature of the debris is unknown. In 2003, an investigation of the former landfill began and all activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM 2003a), and *Draft Sampling and Analysis Plan Addendum for the Former Landfill Site Investigation* (CDM 2005i) which are provided in Appendix A.

During the initial visit in September 2003, vermiculite was observed along a dirt path running east to west through the property, and in a debris pile in the wooded portion of the property. Two surface soil samples were collected from the driveway and yard. Each sample was a 5-point composite and ranged in depths from 0 to 6 inches bgs.

In June 2006, the property was divided into 100-foot by 100-foot grids and surface soil samples were collected from each of the 66 grids. The soil samples were composites ranging from 3 to 5 points and were collected from from 0 to 6 inches bgs.

Refer to Appendix C for additional information on individual sample details and analytical results. One soil sample may have been analyzed by multiple PLM methods, resulting in more analyses than samples collected. Below is a summary of the results by analytical method and LA detection frequency for the 68 total soil samples:

**Former Landfill Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 68 | 62 | 5 | - | - | 1 |
| | PLM-Grav | 7 | 7 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

## 2.5.17 Lincoln County Landfill

A Class IV asbestos landfill was constructed in 2002 for the purposes of disposing asbestos-containing material (ACM) generated during EPA removal actions for the Libby Site. The Class IV asbestos landfill is located west of the existing Lincoln County Class II/III solid waste landfill in Libby, Montana (Figure 2-17). The landfill was designed with four distinct landfill cells, each able to accept waste materials consisting of double-bagged vermiculite, bulk vermiculite insulation, LA-contaminated soils, and LA-contaminated demolition debris. Currently, only one cell has been excavated and continues to be in use. Additional cells may be excavated depending on anticipated future disposal estimates and cell capacity. Additional information on the construction, operations, and maintenance of the asbestos landfill can be found in the *Lincoln County Class IV Asbestos Landfill Operations Plan, Revision 2* (CDM 2008a).

Currently, only vermiculite, LA-contaminated insulation and building debris, and spent PPE are disposed of at the landfill. Contaminated soil is disposed of at the former vermiculite mine (OU3). The following sections describe the various sampling events that have taken place at the Lincoln County Landfill.

### 2.5.17.1 Air

An initial ambient air sampling effort was conducted in June 2001. Four stationary ambient air locations were selected throughout the landfill and sampled for three consecutive days. The four locations were the main entrance, mulch pile, soil pile, and a location directly north of the municipal waste landfill. All samples were collected in accordance with the *Phase 1 QAPP* (EPA 2000b). Sample results are summarized below:

| **Landfill Perimeter Air Sample Results Summary** | | | | | | |
|---|---|---|---|---|---|---|
| | | | **LA Detection Frequency** | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Outdoor Ambient | TEM AHERA | 6 | 6 | - | - | - |
| | PCM* | 12 | 10 | 2 | - | 0.002 – 0.003 f/cc |

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; LA – Libby Amphibole; TEM – transmission electron microscopy; PCM – phase contrast microscopy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter

### 2.5.17.2 Soil

*2001 Compost Stockpile Area Soil Sampling*

One of the initial sampling events at the Lincoln County Landfill occurred in March 2000 when surface and subsurface soil samples were collected from an area where the county prepared and stockpiled compost material. Initial inspections of the compost stockpiles revealed vermiculite throughout the material. The purpose of the sampling was to determine if the compost material contained LA. Three grab samples were collected from the compost material and 28 grab samples were collected from 14 locations where the compost was produced; one surface (0 to 2 inches) and one subsurface (2 to 12 inches) from the each location. All samples were collected in accordance with the *Phase 1 QAPP* (EPA 2000b). Sample results are summarized below.

| 2001 Landfill Compost Stockpile Area Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 17 | 4 | - | 13 | - | - |
| Subsurface | PLM-9002 | 14 | 9 | - | 5 | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

Additional soil samples were collected in 2004 from the compost stockpile and are discussed below. Currently, the compost area is considered to be contaminated with LA and is fenced off from general landfill use. The county anticipates using the area for future municipal waste disposal and is currently working with the EPA on developing a plan to cover the contaminated soil prior to use.

*Pre-Construction Soil Sampling*

During Prior to the asbestos landfill cell construction in July 2002, 29 surface soil samples were collected leading from the landfill entrance to the asbestos cell. The purpose of this sampling event was to obtain background levels of LA along roadways leading to the new cell where haul trucks containing vermiculite insulation would travel. One soil sample, collected from an adjacent draining ditch at the landfill entrance, contained 3 percent LA by PLM-9002. All other soil samples were non-detect for LA by PLM-9002. Results are summarized below:

| Landfill Pre-Construction Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 29 | 28 | - | - | - | 1 |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

During the installation of two groundwater monitoring wells in 2002, two grab soil samples were collected from each of the proposed locations and analyzed for asbestos. One grab surface sample was collected from each well during development from 0 to 24 inches bgs, and another grab subsurface soil sample was collected approximately 118 to 124 inches bgs. Results are summarized below:

| Landfill Well Development Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 2 | 2 | - | - | - | - |
| Subsurface | PLM-9002 | 2 | 2 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

*Trash Area Clearance Soil Sample*

In August 2003, EPA was notified that vermiculite was disposed of on the south side of the municipal waste trash pile. EPA removed the vermiculite and properly disposed of it in the asbestos cell. Once the vermiculite was removed, one surface soil sample was collected from the area where the vermiculite was removed. The sample was collected in accordance with the *Phase 1 QAPP* (EPA 2000b). The sample result is summarized below:

| Landfill Trash Area Clearance Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 1 | 1 | - | - | - | - |
| | PLM-VE | 1 | 1 | - | - | - | - |
| | PLM-Grav | 1 | 1 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

*2004 Compost Stockpile Area Soil Sampling*

During the ongoing investigation activities in Libby, vermiculite was observed in compost material obtained from the Lincoln County Landfill by local residents. Samples of the compost material and soil from the compost area were collected during the 2001 Phase 1 activities as described above. More recent sampling was conducted in May 2004 at the compost stockpile area consistent with the CSS sample collection and analytical procedures. Twenty-one 5-point composite soil samples were collected from areas previously used for mixing, stockpiling, and pick-up of compost materials. All samples were collected in accordance with the *CSS SAP, Revision 1* (CDM 2003a). A detailed summary of the sample collection event, as well as the location and results for the individual samples collected at the compost stockpile area are presented in the *Compost Stockpile Area Sampling Memorandum* (CDM 2004b) which is provided in Appendix A. Sample results are summarized below:

| 2004 Landfill Compost Stockpile Area Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 21 | 8 | 6 | - | 7 | - |
| | PLM-Grav | 19 | 19 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

### 2.5.17.3 Water

Prior to the construction of the project asbestos cells, two groundwater monitoring wells were developed for groundwater sampling purposes. One monitoring well was installed upgradient (CDM-MW-7) and one monitoring well was installed downgradient (CDM-MW-8) of the asbestos landfill and advanced to 259 and 239 feet bgs, respectively.

The monitoring wells were sampled in July 2002 prior to construction and in May 2003 prior to commencement of ACM disposal. The groundwater was sampled for asbestos, volatile organic compounds (VOCs), total petroleum hydrocarbons (i.e., diesel range organics and gasoline range organics), polychlorinated biphenyls (PCBs), priority pollutant 13 metals, and polynuclear aromatic hydrocarbons. Results of these groundwater samples provided baseline groundwater data for the Class IV asbestos landfill. Summary results are included in the *Landfill Operations Plan, Revision 2* (CDM 2008a). Asbestos samples from the initial groundwater samples are summarized below:

| **Initial Landfill Groundwater Results Summary** | | | | | | |
|---|---|---|---|---|---|---|
| | | | **LA Detection Frequency** | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Number of Total LA Structures* | Concentration Range of Detections |
| Water | EPA 100.2 | 2 | - | 2 | 2 | 8,779,661 – 87,796,610 s/L |

*Includes >5 µm structures. Notes: LA – Libby Amphibole; s/L – structures per liter; ND – nondetect

Both monitoring wells are sampled semi-annually in June and December for the same parameters previously mentioned. Results of the semi-annual groundwater sampling event are summarized in individual groundwater monitoring reports produced once analytical data are available. Groundwater sample results collected for LA analysis through the June 2009 sampling event are summarized below:

| **Landfill Groundwater Results Summary Through June 2009** | | | | | | |
|---|---|---|---|---|---|---|
| | | | **LA Detection Frequency** | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures* | Concentration Range of Detections |
| Water | EPA 100.2 | 25 | 25 | 1 | 3 | 2,633,898 s/L |

*Includes >5 µm structures. Notes: LA – Libby Amphibole; s/L – structures per liter; ND – nondetect

### 2.5.17.4 Asbestos Cell Capacity

Approximately 38,250 bank cubic yards (BCY) of ACM (i.e., vermiculite, LA-contaminated building material, spent PPE, and plastic sheeting, etc.) have been disposed of in the Lincoln Country Class IV asbestos landfill since its construction. Additionally, 5,230 cubic yards ($yd^3$) of LA-contaminated riprap from the creeks were disposed of in the landfill during the 2008 and 2009 construction season.

In order to estimate landfill capacity needs, it was necessary to estimate the remaining removal actions requiring disposal at the landfill, and future compaction of disposed materials. Several assumptions were made regarding the remaining number of known interior removal actions at OU4 and OU7, anticipated removal actions arising from properties yet to be investigated, future removal actions at the Libby Elementary School (Section 2.19.6) and Central Maintenance Building at OU5, and slope requirements to ensure positive drainage. Once the misting tent is relocated from the bottom of the eastern side of the cell, it can be assumed that the present capacity of the cell is sufficient to accommodate all the remaining waste and the cell has surplus space for unforeseen disposal needs. The excess capacity of Cell 1 was estimated at approximately 58,000 BCY.

Assumptions and calculations regarding future landfill requirements are provided in Appendix G. These estimates assume that only vermiculite and associated LA-contaminated debris are disposed of in the landfill and all soils are transported and disposed of at the former mine. If in the future, changes in the disposal operation are considered, the calculations will have to be adjusted to reflect the additional volumes.

## 2.5.18 Borrow Sources

Once LA-contaminated soil is removed from properties, various types of fill materials are used to backfill excavated areas. In general, fill materials consist of topsoil and topsoil amendments, common fill, structural fill, and sand. Prior to use, samples are collected from borrow sources, either in situ or stockpiled, to determine if they contain LA, organic, and organic contaminants (above background levels), and to ensure they meet project-specific physical characteristics. Given the agitated nature of borrow sources, all samples collected are considered subsurface.

### 2.5.18.1 Fill Material Parameters

All fill materials are sampled for LA in 3,000 $yd^3$ increments. In addition, all fill materials are sampled for a suite of organic and inorganic parameters in 5,000 $yd^3$ increments (sand and topsoil amendments are sampled once per season). Topsoil is sampled for a suite of agronomy parameters and common fill is sampled for gradation to determine if they meet project specifications. The following table outlines fill material sample frequency:

| Parameter | Frequency | Acceptable Limit |
|---|---|---|
| LA | 3,000 $yd^3$ | Non-detect |
| Organic/inorganic analyses[1] | 5,000 $yd^3$ | At or below background levels[2] |
| Agronomy[3] (topsoil only) | 5,000 $yd^3$ | Within contract specifications |
| Gradation[4] (common fill only) | 5,000 $yd^3$ | Within contract specifications |

Notes: LA - Libby Amphibole; $yd^3$ - cubic yards
[1]VOCs, SVOCs, PCBs, TPH, herbicides, pesticides, and target analyte list metals
[2]Results were compared to the soil contamination action limits based on Montana Tier 1 Surface Soil Table and EPA Region 9 Preliminary Remediation Goals.
[3]Agronomy analyses include soil texture, pH, organic matter, sodium absorption ratio, electrical conductivity, cation exchange capacity, and plant available nitrogen, phosphorus, and potassium.
[4]Gradation is performed on common fill on the 3-inch, No. 4, 40, and 200 sieves.

Results of these tests were evaluated by qualified project personnel prior to government use. Once it was determined the fill material met project specific requirements, it was used for restoration purposes.

*Topsoil Parameters*
Topsoil specifications for OU4 restoration efforts have changed over the course of the project. Changes were made, based on lessons learned and availability of topsoil in the Libby valley, to improve topsoil performance for settling, drainage, and sustaining restoration efforts (e.g., sod, hydroseed, shrubs, etc.). As of December 2009, four different topsoil specifications have been used:

- 2002 Topsoil Specification – Used 2002 through June 2005 (Appendix A)
- June 2005 Topsoil Specification – Used June 2005 through 2006 (Appendix A)
- January 2006 Topsoil Specification – Used 2007 through October 2009 (Appendix A)
- 2009 Topsoil Specification – Used October 2009 through present

*Common Fill Parameters*
Two different common fill parameters were used over the course of the project. Similar to topsoil, the common fill parameters changed to improve performance of the sub-base material. As of December 2009, two different common fill specifications have been used:

- Section 02200: Residential Earthwork – Used 2002 through October 2009 (provided in Appendix A)
- Common Fill Specification - Used October 2009 through present

*Structural Fill Parameters*
Only one type of structural fill specification has been used over the course of the project (Appendix A):

- Section 02200: Residential Earthwork – Used 2002 through present

### 2.5.18.2 Fill Material Sampling

Samples were generally collected in a two-step process; asbestos content followed by contract-specific parameters and a suite of organic and inorganic parameters as described above. Topsoil source areas were sampled either in situ (unblended with amendments) or stockpiled (unblended or blended with amendments). In some cases, topsoil amendments (e.g., mulch, sand, etc.) were sampled prior to mixing so as to not taint the stockpile with contaminated additives. Common fill, structural fill, and sand were generally sampled from the suppliers' source stockpiles.

Prior to 2008, LA samples collected from potential fill material source areas were analyzed by PLM-9002. On occasion, some samples (14 out of 207) collected prior to 2008, were analyzed by PLM-VE. Beginning in 2008, at the direction of EPA, all fill material samples collected for LA were analyzed by PLM-VE. Fill material samples that were analyzed for LA content are summarized below. Refer to Appendix C for additional information on individual sample details and analytical results.

**Fill Material Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Subsurface | PLM-9002 | 207 | 203 | - | 2 | 2 | - |
| | PLM-VE | 111 | 104 | 7 | - | - | - |
| | PLM-Grav | 61 | 61 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

If the sample result for the fill material source was non-detect for LA, contract-specific (i.e., agronomy or gradation) and organic/inorganic samples were collected. The fill material samples analyzed for other parameters (i.e., organic/inorganic analyses, agronomy, gradation) are not available in the project database, but are available upon request.

### 2.5.18.3 Borrow Source and Fill Material Locations

Several source areas throughout OU4 were sampled as potential fill material source pits. Not all areas sampled were used for fill material as many locations, at the government's request, were sampled prior to contract award. In addition, fill material source areas with detectable levels of LA were either not used or a different location was selected and re-sampled. Each of the borrow sources sampled in the Libby valley are shown on Figure 2-19.

## 2.5.19 Periodic Monitoring at Project-Related Facilities

EPA performs periodic monitoring at several OU4 locations at which activities are conducted that may increase the potential for LA contamination. The purpose of the monitoring is for personnel health and safety, and, as applicable, to help ensure project samples and equipment are handled in atmospheres free of LA. The locations where periodic monitoring has been or currently is conducted are:

- 107 West 4th Street (onsite asbestos laboratory)
- 501 Mineral Avenue (former EPA Information Center location)
- 108 East 9th Street (current EPA Information Center location)
- 115 and 119 East 6th Avenue (Libby Fire Department)
- 1263 Highway 37 (Libby sample warehouse)

- 318 Louisiana Avenue (former CDM office)*

*The current CDM office is periodically monitored, but will be assessed in a future OU5 RI report.

- 1673 Highway 37 (former MARCOR office)

Monitoring typically consists of collecting indoor ambient air samples, although indoor dust samples have also been collected. If any sample yields detectable levels of LA, work and housekeeping practices may be evaluated and the work area cleaned. EPA has collected a total of 377 indoor ambient air and 188 indoor dust periodic monitoring samples. The results are provided in Appendix C and compiled in the following tables:

**Periodic Air Monitoring Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | |
|---|---|---|---|---|---|---|
| | | | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor Ambient | TEM ISO | 7 | 6 | 1 | 2 | 0.00587 s/cc |
| | TEM AHERA | 359 | 350 | 9 | 1 – 4 | 0.00272 – 0.01515 s/cc |
| | PCM* | 51 | 5 | 46 | - | 0.001 – 0.040 f/cc |

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; AHERA – Asbestos Hazard Emergency Response Act; s/cc – structures per cubic centimeter; PCM – phase contrast microscopy; f/cc – fibers per cubic centimeter

**Periodic Dust Monitoring Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | |
|---|---|---|---|---|---|---|
| | | | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor | TEM ISO | 37 | 31 | 6 | 1 – 3 | 36 – 506 s/cm$^2$ |
| | TEM AHERA | 151 | 150 | 1 | 1 | 446 s/cm$^2$ |

Notes: LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; AHERA – Asbestos Hazard Emergency Response Act; s/cm$^2$ – structures per square centimeter

## 2.6 Natural Resource Conservation Service

In 2002, the Natural Resource Conservation Service requested several samples of vermiculite for their use. Samples of exfoliated vermiculite, unprocessed vermiculite, and processed vermiculite were identified and sent offsite. Analytical results for these samples are not available in the project database.

## 2.7 Sediment Core Pilot Study

In June 2002, EPA began a pilot study to assess sediment deposition in several lakes surrounding the Libby valley. A total of 69 core samples were collected from Flower Lake and St. Mary's Lake (depicted on Figure 2-17). Sediment cores were collected in accordance with *Sampling and Quality Assurance Project Plan for Measurement of Historic Fiber Deposition Rates in Sediment* (EPA 2002b). Analytical results for these samples are not available in the project database. Where are they? - Part of OU 4

## 2.8 Post Cleanup Evaluation Study

Post-cleanup evaluation sampling was performed between November 2003 and February 2004 in accordance with the *Final Sampling and Analysis Plan Addendum, Post Cleanup Evaluation Sampling* (CDM 2003f) which is provided in Appendix A. Three types of field samples (stationary indoor air, personal air, and dust) were collected during the cleanup evaluation (CE) activities.

The purpose of the evaluation was to:

- Determine the magnitude of post-cleanup residual contamination levels under varying conditions.
- Understand the time periods that indoor contamination levels may remain below the acceptable cleanup criteria under varying conditions.
- Evaluate if certain residual sources such as dust inside air ducts and furnaces, or in carpets and upholstery, may result in recontamination of indoor dust.

Thirty-one houses were included in the CE and their selection was prioritized according to the six criteria listed below. A detailed explanation of the distribution, including number and percentage, of the 31 properties related to each of the criteria is available in the *Final Post Cleanup Evaluation Sampling Technical Memorandum* (CDM 2004c) which is provided in Appendix A.

- Interior cleaning must have occurred – this could be a vermiculite insulation removal, an interior cleaning due to visible vermiculite in the living space, elevated dust results, or both.
- Since a limited number of houses in the area use forced air heating, these houses were preferentially included. Houses that use radiant heating were also sampled.
- Houses where vermiculite was left in place (i.e., walls, crawlspaces, subfloors).
- Properties that had a longer duration between the original cleanup and the CE.
- Properties where an interior cleaning was conducted due to high dust results, but carpeting was not removed.

- Properties that, in addition to an indoor removal action, had an outdoor removal requiring removal of most of the yard.

## 2.8.1 Air

### 2.8.1.1 Stationary Air

A total of 69 stationary indoor air samples were collected in 31 houses in accordance with the *Phase 1 QAPP* (EPA 2000b). High volume air pumps were used to collect one stationary air sample per floor of the living space during normal living conditions. If needed, additional samples were collected depending on the square footage of each floor. Each sample was collected in a centrally located area to avoid interference from outside air.

In order to achieve the desired analytical sensitivity a total air volume between 6,000 and 8,000 liters was pulled through each 25 millimeter (mm) 0.8 μm MCE sampling filter at a flow rate that captured this volume in one 10 to 12 hour period.

All stationary air samples were analyzed by TEM AHERA with an initial target sensitivity of 0.0001per cubic centimeter ($cc^{-1}$), and a supplemental sensitivity of 0.0002 $cc^{-1}$ if the initial sensitivity could not be met. Of the 69 stationary air samples collected, only four samples had detectable concentrations of LA ranging in from 0.00010 s/cc to 0.00020 s/cc. Analytical results for all remaining stationary air samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.8.1.2 Personal Air

A total of eight personal air samples were collected in five houses in accordance with the *Phase 1 QAPP* (EPA 2000b). In order to achieve the desired analytical sensitivity, an approximate total air volume of 6,000 liters was collecting during 8- to 10-hour periods over the course of 2-3 days. Personal air samples were collected on a single 25 mm 0.8 μm MCE sampling filter at a flow rate between 1 to 4 liters as determined by conditions and equipment. Personal air and stationary air samples were collected at approximately the same flow rate to help ensure that the same volume of air was collected during the same time period for both the personal and stationary air samples.

During the collection of personal air samples, each resident being sampled completed an activity log which collected information concerning the activities they performed while wearing the sampling pump. Residents were instructed that during the time of sample collection, that if they left their property, they should turn off the air pump. If the occupant wearing the pump exited the house, but remained outdoors on their property, the sampling included this period of time.

All personal air samples were analyzed by TEM AHERA with an initial target sensitivity of 0.0001 $cc^{-1}$, and a supplemental sensitivity of 0.0002 $cc^{-1}$ if the initial sensitivity could not be met. Only one of the eight personal air samples collected during the CE activities had detectable concentration of LA of 0.0001 s/cc. The seven remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.8.2 Dust

A total of 32 dust field samples were collected from 31 houses. As detailed in the *Post Cleanup Evaluation Sampling and Analysis Plan* (CDM 2003f), dust samples were collected in accordance with the *Sampling and Analysis Plan for Indoor Dust* (EPA 2003b), with the following exceptions:

- One dust sample was collected per house.
- Each dust sample was a minimum of a 400 $cm^2$ composite that was collected over all floors (i.e., basement, ground floor, second floor, etc.).
- For multiple floor houses, one 100 $cm^2$ high traffic area and one 100 $cm^2$ horizontal surface sample was collected from each floor on a single sample cassette.
- For single floor houses, two 100 $cm^2$ high traffic areas and two 100 $cm^2$ horizontal surfaces were collected from each floor on a single sample cassette.

All dust samples were analyzed by TEM AHERA with a target sensitivity of 500 $cm^{-2}$. Analytical results for all samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

## 2.9 Supplemental Remedial Investigation

As part of the ongoing response in Libby, EPA identified a number of uncertainties and data gaps that required further investigation, and developed a Supplemental Remedial Investigation Quality Assurance Project Plan (hereafter referred to as "SQAPP") to guide the collection of additional data needed to help strengthen final decision-making at the Libby Site. SQAPP sampling was conducted between June 2005 and October 2006 and air, dust, and soil samples were collected, handled, and analyzed in accordance with the *Final Supplemental Remedial Investigation Quality Assurance Project Plan* (EPA 2005b) which is provided in Appendix A. Twelve areas of investigation were identified in the SQAPP, and involved sample collection at 58 properties (Figure 2-20):

- Task 1: Estimation of Soil Contribution to Indoor Dust
- Task 2: Estimation of Dust to Indoor Air Transfer
- Task 3: Estimation of Soil to Outdoor Air Transfer
- Task 4: Detection Limits for Soil Methods

- Task 5: Concentration in Soil that is Non-detect by PLM-VE
- Tasks 6-9: Time Trends in Asbestos Levels in Air and Dust in Remediated Buildings
- Task 10: Dust Concentrations under Carpets
- Task 11: Safety Factor
- Task 12: Re-analysis of Ambient Air and Perimeter Air Samples

The first group of tasks (Tasks 1-5) was mainly designed to help improve EPA's ability to evaluate human exposure to asbestos in the house and residential environment. The second group of tasks (Tasks 6-12) was designed to help evaluate the efficacy of EPA's cleanup activities. The results of this investigation were extensively summarized in the *Summary Report for Data Collected under the Supplemental Remedial Investigation Quality Assurance Plan* (EPA 2007a) which is provided in Appendix A. The remainder of this section summarizes the results of the samples collected and provides the conclusions as detailed in the SQAPP Summary Report (EPA 2007a).

### 2.9.1 Air

A total of 226 air samples were collected between June 2005 and October 2006 as part of the SQAPP investigation. The following table summarizes the type of air samples collected to support the SQAPP sampling event:

| Summary of SQAPP Air Sample Types Collected | |
|---|---|
| **Type of Sample Collected** | **Number of Samples Collected** |
| Indoor Stationary | 45 |
| Indoor Personal | 24 |
| Outdoor Stationary | 90 |
| Outdoor Personal | 67 |

Air samples were analyzed by TEM ISO with the modification to include LA structures with an aspect ratio ≥ 3:1. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical methods and LA detection frequency for the 226 total air samples.

| SQAPP Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Indoor Stationary | TEM ISO | 45 | 13 | 32 | 1 - 14 | 0.00005 - 0.00247 s/cc |
| Indoor Personal | TEM ISO | 24 | 9 | 15 | 1 -6 | 0.00013 - 0.00663 s/cc |
| Outdoor Stationary | TEM ISO | 90 | 72 | 18 | 1 - 109 | 0.00088 - 0.69280 s/cc |
| Outdoor Personal | TEM ISO | 67 | 29 | 38 | 1 - 106 | 0.00085 - 1.3966 s/cc |

Notes:; s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; LA – Libby Amphibole

## 2.9.2 Soil

Between June and July 2005, a total of 73 composite surface soil samples were collected. Depending on the subtask, the composited soil samples ranged from 3- to 15-point composites and were collected from depths ranging from 0 to 6 inches bgs. Soil samples were collected in accordance with CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection, Revision 1.*

A total of 73 soil samples were analyzed by PLM-VE and PLM-Grav (if applicable). Thirty-seven samples were non-detect by both PLM methods, and the remaining samples had detectable concentrations of LA ranging from trace to 1percent LA. Refer to Appendix C for additional information on individual sample details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 70 total soil samples:

| SQAPP Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 73 | 37 | 28 | - | 7 | 1 |
| | PLM-Grav | 4 | 4 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

## 2.9.3 Dust

For the tasks that required microvacuum dust sampling, dust samples were collected in accordance with ASTM D5755 with modifications as described in the *Sampling and Analysis Plan for Indoor Dust* (EPA 2003b). The procedure was modified to increase the number of 100 $cm^2$ subareas depending upon amount of dust present beneath carpets. For the task that required high volume dust sampling, dust samples were collected in accordance with SRC-DUST-01, *High Volume Indoor Dust Sampling at Residences for Determination of Risk-Based Exposure to Metals* (SRC 2004).

Dust samples collected as part of the SQAPP were analyzed by TEM ISO, and TEM AHERA with SQAPP-specific counting rule modifications (specified in Appendix E of the SQAPP). These modifications included changing the recording rule to include structures with an aspect ratio ≥ 3:1.

A total of 60 dust samples were collected between June 2005 and October 2006. Refer to Appendix C for additional information on individual sample details and analytical results. The results are summarized below:

- A total of 48 samples were analyzed by TEM AHERA, of these samples:
  - 33 samples were non-detect for LA
  - 15 samples had detectable concentrations of LA ranging from 4 to 753 s/cm$^2$
- A total of 12 samples were analyzed by TEM ISO, of these samples:
  - 8 samples were non-detect for LA
  - 4 samples had detectable concentrations of LA ranging from 181 to 1,585 s/cm$^2$.

### 2.9.4 Findings of the SQAPP

The major findings, conclusions, and observations of the *SQAPP Summary Report* (EPA 2007a) are summarized in this section.

*Releases from Outdoor Soil to Air*
When outdoor soil that contains LA is disturbed (e.g., by raking, mowing, or digging), fibers are released into the breathing zone of the person who is causing the soil disturbance. The concentration of fibers that are released into the air is highly variable, both within and between differing types of disturbance activities, but there is a clear trend for levels in air to increase as the levels in soil (as measured by a polarized light microscopy method referred to as PLM-VE) increase.

*Exposures in Indoor Air*
Measurement of LA levels in indoor air of typical residences in Libby reveals that concentrations are usually higher in the breathing zone of residents (measured using personal air monitors) than in general room air (measured using stationary monitors), and that levels are generally higher when an individual is engaged in active behaviors (cleaning, sweeping, moving about) than in passive behaviors (sitting, reading, etc.).

*Dust as a Predictor of Indoor Air Exposures*
EPA began the SQAPP investigation with the assumption that the main source of LA in indoor air was likely to be contaminated indoor dust that was resuspended into indoor air by human activity or by mechanical forces (e.g., air flow from a furnace).

Is this being pursued? address in OU4 ABS

However, paired measurements of indoor air and indoor dust collected during the SQAPP did not reveal any clear relationship. The basis for this apparent lack of correlation is not known.

*Levels of LA in Outdoor Ambient Air*

One exposure pathway that applies to all people in Libby is inhalation of outdoor ambient air. Prior to the SQAPP, a total of 404 outdoor ambient air samples had been collected, but most of these were not analyzed with an analytical sensitivity needed to provide an accurate estimate of the true concentration. Therefore, as part of the SQAPP, a subset of 33 of these samples was selected for supplemental analysis to achieve an analytical sensitivity that was about 25 times lower than the original sensitivity. Comparing the original results to the re-analyses indicated that the estimated mean value decreased about two-fold (from 0.00055 s/cc to 0.00021 s/cc), and uncertainty around each value narrowed substantially. However, these air samples were not collected in a way that ensured they were spatially or temporally representative.

*Transfer of Soil into Indoor Dust*

EPA generally assumes that outdoor soil is an important contributor to indoor dust. That is, if outdoor soil is contaminated with LA, any soil that is tracked into the house may contaminate the indoor environment. The SQAPP data collected suggested that the amount of soil transferred to indoor dust depends upon the condition of the yard and the number of people and pets entering/exiting the house on a regular basis. On average, the transfer factor was about 0.002 g soil/cm$^2$. However, this transfer factor yields predicted levels of LA in indoor dust that are substantially higher than measured levels, indicating that the factor should not be used to predict indoor dust levels until the basis of the discrepancy is resolved.

So is this value too high? Do we need to refine this value in the field?

*LA Levels in Soil that are non-detect by PLM*

EPA uses PLM-VE to estimate levels of LA in soil in Libby. This is a semi-quantitative method that reports a sample as non-detect when the microscopist cannot recognize any LA in the sample. However, from the studies of outdoor soil disturbance, it is evident that soils that are non-detect can release LA fibers to air. For this reason, EPA used more powerful electron microscopic methods to estimate the average level of LA in soils that were non-detect by PLM-VE. The results were variable between samples, but the average is approximately 0.05 percent by mass.

*LA Levels in Dust Under Carpets*

One source of potential concern to EPA is LA fibers that may be trapped under carpets. In order to obtain preliminary data, EPA sampled dust under 12 carpets in Libby. Four of the samples contained detectable levels of LA, with observed LA concentrations ranging from 180 to 1,600 s/cm$^2$. These all occurred in carpets that were more than 10 years old. While the small amount of data collected from this pilot-scale investigation is too limited to draw firm conclusions, these results indicate that LA may occur in dust under some carpets, with an apparent tendency for levels to be higher for older carpets. The degree to which dust under carpets contributes to levels of LA in indoor air is not known, and more data would be needed to determine whether dust under carpets represents a significant residual source of LA in indoor air.

*Time Trends in Air and Dust after Cleanup is Completed*
In order to determine if a property cleanup remains effective over time, EPA collected indoor air and dust data for a period of up to 16 months following indoor cleanup at four properties. No upward time trends in dust were apparent, but an increase in LA concentrations in indoor air did occur in two houses at the 16 months time period. The reason for this apparent increase is not known. Additional long-term monitoring would be needed to provide information on whether potential recontamination is occurring due to residual sources.

*Releases to Air from EPA Cleanup Activities*
EPA employs a range of strategies to minimize releases of asbestos during soil cleanup activities. In order to evaluate the effectiveness of these control strategies, EPA routinely collects samples of air from monitors placed around the perimeter of cleanup activities. In general, the detection frequency of LA in these samples is low, and there is an apparent tendency for the most recent values to be lower than the earliest values. This trend is suspected to be attributable to the fact that the level of contamination in soil and waste material was higher at the first locations that were addressed (the Screening and Export Plants) than at the residential and commercial areas that are currently being addressed. However, analytical sensitivities for many of these perimeter air samples were too high to support reliable conclusions on the actual concentration values in the air. Therefore, as part of the SQAPP, 20 perimeter air samples were re-analyzed to obtain an analytical sensitivity that was about five-fold lower than in the original samples. The mean concentration based on the re-analyses (0.0005 s/cc) is about four-fold lower than was estimated previously for the same samples, and within a factor of about 2 of the average value in outdoor ambient air.

## 2.10 Cumulative Risk Assessment

Prior to December 2005, most of the air sample data collected by EPA used stationary and/or personal air monitors at specific locations around the Libby Site. Because no data had yet been collected for individuals with varying levels of LA exposure at multiple indoor and outdoor locations, EPA implemented a study to measure such exposure. The pilot investigation for cumulative risk was intended to provide information concerning: 1) the sampling issues and problems associated with performing cumulative exposure assessments on individuals; and 2) the cumulative exposures that are experienced by EPA staff and/or contractors that are moving around town, but not directly involved in vermiculite or asbestos cleanup activities.

Eleven cumulative personal air samples were collected in December 2005 in accordance with the *Sampling and Analysis Plan for Cumulative Inhalation Exposures in*

*Libby, Montana* (EPA 2005c) which is provided in Appendix A. Sample results are compiled in the following table:

| Cumulative Risk Assessment Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | |
| Sample Type | Analytical Method | Number of Analyses | Number of ND Samples | Number of Detects | Number of Total LA Structures | Concentration Range of Detections |
| Personal Indoor and Outdoor | TEM ISO | 11 | 8 | 3 | 1 | 0.00009 – 0.00010 s/cc |

Notes: LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; PCM – phase contrast microscopy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter

Due to the complexity of collecting personal air samples over prolonged periods of time (i.e., days) and the inability to correlate sampling results to specific activities that may cause exposure, no additional cumulative risk sampling was conducted. Rather, activity-based sampling (ABS), as discussed in Section 2.13 of this report, was initiated to gather exposure data at OU4.

# 2.11 Ambient Air Program

## 2.11.1 2000 to 2003 Summary

One pathway of exposure that applies to all residents and workers in Libby is inhalation of ambient outdoor air. Beginning around 2000 and continuing through 2003, EPA collected outdoor ambient air samples of opportunity (or in conjunction with cleanup monitoring activities and existing air monitoring programs) at a number of locations around Libby. While these samples were not collected under a SAP specifically designed to determine outdoor ambient air levels, the data were culled from various collection efforts in order to gain an initial understanding of the levels of LA typically observed in outdoor air. These data were summarized in an internal draft report prepared in 2004 (CDM 2004d).

One group of opportunistic samples was collected from an existing air monitoring station maintained by the Lincoln County Environmental Health Department (LCEH). LCEH personnel collected outdoor ambient air samples between September 2001 and September 2002 from the station located at the Lincoln County Courthouse Annex building which serves as the state's particulate matter monitoring site (AIRS Site 30-053-0018). This air monitoring station is located in the downtown area of Libby (418 Mineral Avenue) and is approximately 25 feet above street level. In total, 46 outdoor ambient air field samples were analyzed by TEM ISO. A portion of the field samples were also analyzed by PCM. Results for the field samples are summarized as follows:

| Lincoln County Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Outdoor Ambient | TEM ISO | 46 | 41 | 5 | 1 - 5 | 0.00010 – 0.00086 s/cc |
| | PCM* | 31 | - | 31 | - | 0.001 – 0.034 f/cc |

Based on units, these are PCM fibers?

Notes: *PCM results are for total fibers and cannot be reported as concentrations of LA because the method does not determine fiber mineralogy; LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; PCM – phase contrast microscopy; s/cc – structures per cubic centimeter; f/cc – fibers per cubic centimeter

Air samples collected by EPA personnel or contractors during the 2000 to 2003 time period were collected in accordance with the following guidance documents:

- *Phase 1 QAPP* (EPA 2000b)
- Removal Action Sampling and Analysis Plan for Confirmation Sampling of Soil and Perimeter and Personal Sampling of Air for Asbestos (CDM 2000)
- Property-Specific Sampling and Analysis Plan for Air and Dust Sampling for Stimson Lumber Company (CDM 2002d)
- Final Response Action Sampling and Analysis Plan (hereafter referred to as the *RA SAP*) (CDM 2003c, Appendix A)

Sample position was determined by field personnel at the time of sample collection. Factors such as wind direction, location of contaminant, and exclusion zone boundary are considered when the air sample is positioned.

***Results Summary***

Ambient air data (Appendix C) have been collected at a total of 22 different locations in and around Libby. The detection frequency of countable structures by PCM is relatively high (50 percent), while detection frequencies for TEM AHERA and TEM ISO are lower (4 percent and 2 percent, respectively). Of the 22 locations, particles of LA have been detected by TEM in five locations, with no LA detected at the other 17 locations. Observed concentration values (i.e., detects only) are relatively low (an average of 0.002 s/cc by TEM ISO, 0.005 s/cc by TEM AHERA, and 0.011 by PCM). Average concentrations (i.e., including both detects and non-detects) depend on the method used to evaluate non-detects. Assuming a value of ½ the detection limit, concentration values average about 0.002 - 0.003 s/cc by TEM. As noted previously, concentration values estimated by PCM tend to be higher than by TEM, and this is likely due to the presence of various types of non-asbestos fibrous material.

Data for perimeter air samples are presented in Appendix E, and these data are summarized. Because there have been a large number of different locations where perimeter air samples have been collected, the data are simply grouped by year rather than by location. All perimeter samples have been analyzed by TEM AHERA. The following table summarizes the results for the perimeter air samples:

| **Summary of 2000 to 2002 Perimeter Air Samples** | | | | | |
|---|---|---|---|---|---|
| Year | Method | Total Samples | Detects | Concentration (s/cc) Detects Only | |
| | | | | Avg | Max |
| 2000 | TEM AHERA | 430 | 8 | 0.0041 | 0.0050 |
| 2001 | TEM AHERA | 610 | 30 | 0.0110 | 0.0480 |
| 2002 | TEM AHERA | 754 | 9 | 0.0067 | 0.0150 |
| **Total** | TEM AHERA | 1794 | 47 | 0.0090 | 0.0480 |

As shown in above, a total of 1,794 perimeter air samples have been collected at various properties around Libby where removal of asbestos-contaminated soil has occurred. Of these samples, 47 (2.6 percent) were observed to contain LA. Nearly all of these contained only one LA structure, with only eight (0.4 percent) containing two or more structures. None of the samples were above the OSHA standard of 0.1 s/cc (max detect = 0.048 s/cc). In accordance with governing documents, at the eight properties where more than one structure was observed, engineering controls were adjusted and corrective measure taken immediately following the review of the results to ensure that releases to ambient air due to cleanup activities were not occurring.

*Study Conclusions*

The conclusions of the CDM 2004 draft report were:

- LA fibers were found to occur in outdoor ambient air samples collected around the Libby community.
- Sources of the LA fibers found in outdoor ambient air in Libby could not be identified with certainty, but windborne transport of fibers present in soils and dust around the community was identified as one component that was likely to be significant.
- Concentration levels did not appear to be substantially different at different locations within the main residential-commercial section of Libby, but there was a slight tendency for values to be higher in areas closest to the mine.
- Data were too limited to determine if any time trend towards changed levels in outdoor ambient air was occurring as a result of ongoing EPA cleanup activities.
- If an individual were exposed to ambient air continuously (24 hours per day) for a lifetime, cancer risk estimates would be within EPA's risk range of 1E-04 to 1E-06.

EPA (CDM 2006d) reviewed the draft report, and identified a number of limitations, including the following:

- Data presented in the draft are incomplete because of lack of seasonal and geographic representation over time, and there are an insufficient number of data points at adequate sensitivity.
- The analysis presented in the draft document preliminarily assumes that "non-detect" values are equal to zero.
- The methodology for estimating risk ranges is preliminary and should be considered draft.
- Evaluation of risks in the draft document is limited to a single pathway and does not address cumulative exposure from multiple pathways at the Libby Site.

Based on these limitations, EPA determined that the outdoor ambient air data, while useful to provide initial impressions of outdoor ambient air levels, were not sufficiently extensive or representative in time and space to draw strong conclusions regarding the true levels of exposure and risk from ambient air. Consequently, EPA determined that there was a need for the collection of additional ambient air data that would be sufficiently representative and of adequate quality to estimate human health risks associated with inhalation of LA in outdoor ambient air in and around the Town of Libby, and to characterize spatial patterns and temporal trends of LA occurrence in outdoor ambient air. These additional data were collected during the 2006 to 2008 ambient air investigation (Section 2.11.2).

### 2.11.2 2006 to 2008 Summary

As mentioned in Section 2.9.4, ambient air samples collected before 2006 were insufficient to provide spatial and temporal representativeness. An OU4 Ambient Air Investigation was conducted from October 2006 to June 2008 in accordance with the *Final Sampling and Analysis Plan for Outdoor Ambient Air Monitoring at the Libby Asbestos Site* (CDM 2006d), and *Final Sampling and Analysis for Outdoor Ambient Air Monitoring at the Libby Asbestos Site, Revision 1* (CDM 2006e). The results of the investigation were summarized in the *Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Site, Libby, Montana (October 2006 to June 2008)* (EPA 2009c), but only those monitoring locations at OU4 are described below. Copies of all referenced documents above are provided in Appendix A.

***October 2006 to September 2007 Sample Design***

Outdoor ambient air sampling began in October 2006 at 14 sampling stations in the community of Libby and at two off-site reference stations. For the first year of the program, outdoor ambient air sampling was conducted at 14 stations at OU4 (Figure 2-21). The number and location of stations were selected so that the study area could be divided into four sub-areas (north, east, central, south) to allow for evaluation of spatial variability in long-term averages. In addition, reference stations were established in Eureka and Helena, Montana. The purpose of these stations was to establish a frame of reference to which observations in Libby could be compared. The location of one station was changed after 16 sampling events (on March 28, 2007) due to repeated vandalism. The new station (J. Neils Park) is located a short distance south of the original station (1427 Highway 37).

Outdoor ambient air samples were collected and equipment was calibrated in accordance with CDM-LIBBY-07, *Collection of Outdoor Ambient Air Samples* for asbestos air sampling. At each of the stations in Libby, samples were collected over a 6-day interval, with five days between each interval.

Two samples were collected at each station. One sample was collected at a flow rate of 1.4 liters (L) per minute (L/min), which resulted in a total volume over 6 days of about 14,000 L. This sample is referred to as the high volume sample. Additionally, a second sample was collected at a flow rate of 1.0 L/min over the same period of time and is referred to as the low volume sample. This sample was collected to serve as a backup for use if the high volume sample was overloaded or damaged.

Samples were collected using 25-mm diameter, 0.8 µm pore size MCE filter cassettes. In order to investigate whether the choice of pore size is an important determinant of observed concentrations, samples using 0.45 µm pore size filters were collected intermittently at selected stations. These stations were selected so that sampling stations from the each study area were represented.

Samples were collected at approximately 5 to 6 feet above ground level at all stations. This height was selected because it represents the breathing zone height of most adults. In order to investigate whether levels might be different at a child's breathing height (3 feet), samples were intermittently collected 3 feet above ground level at selected sampling locations. As above, these locations were selected to represent each study area.

***September 2007 to June 2008 Sample Design***

At the conclusion of the first year of sampling, the sampling design was reevaluated and only seven of the monitors were retained for continued monitoring into year 2 (after September 16, 2007). Likewise, of the two original reference stations, one (Helena) was retained for continued monitoring.

Samples collected after September 16, 2007 were collected using the same equipment and techniques as described above. However, the sampling schedule was revised to be 5 days of sample collection followed by 10 off (non-collection) days. Originally, it was planned that monitoring would continue at all of these stations for one additional year. However, because the observed concentration values continued to be relatively low, sampling at the OU4 stations was discontinued in December 2007, while sampling at the OU2, OU6, and Helena stations continued through June 2008.

All outdoor ambient air and QC samples were submitted to the analytical laboratory for analysis by TEM ISO, with a number of project-specific modifications described in the governing documents (CDM 2006d and CDM 2006e). The target analytical sensitivity for all samples was 0.00004 $cc^{-1}$.

A total of 590 OU4 ambient air samples were analyzed as part of the 2006 to 2008 OU4 ambient air investigation. Of these 590 samples, 511 were non-detect for LA. The remaining 79 samples had detections of LA concentrations ranging from 0.00004 to 0.00053 s/cc. Refer to Appendix C for additional information on individual sample details and analytical results.

511/590 = 87% ND

*Study Conclusions*

The conclusions from the *Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Site, Libby, Montana (October 2006 to June 2008)* (EPA 2009c) include the following:

- Concentration levels of LA in ambient air tend to be very low in winter, and higher in the middle to late summer, when conditions are usually dry. and dusty
- Mean concentrations of LA tend to be somewhat higher in the northern and eastern portion of Libby than in the central and southern regions, although these differences are not statistically significant.

## 2.12 Dust Pilot Study

In order to investigate the usefulness and reproducibility of dust sample results collected at OU4, a dust pilot study was initiated in 2007 in accordance with the *Dust Composite Sampling Pilot Study* (CDM 2007a) which is provided in Appendix A.

It is generally believed that LA contamination in indoor dust is likely to be an important contributor to LA contamination in indoor air. However, it is expected that the level of LA in indoor dust (expressed as LA s/$cm^2$) may not be constant throughout the house, and that there may be differences between sub-locations. The purpose of the pilot study was to:

1) Investigate whether or not there is substantial variability in LA levels in dust loading (structures per cm2) as a function of the "accessibility" of an area, and/or the nature of the surface (porous vs. hard).

2) Determine if collecting a dust sample based on a large number of templates (30) will yield a sample that is more nearly representative of a floor than a set of six templates. If so, the degree of difference in the two approaches was investigated in two ways:

    a) Investigate the degree of correlation between the results of the paired (same floor) 30-point composites and the mean of two 3-point composites.

b) Invest igate the relative precision of the two approaches. That is, at a number of properties, two 30-point composites and two sets of two 3-point composites were collected.

3) Determine if the length of time is a source of potential variation in sample results by pairing 30-point composite samples using 30-second with 120-second vacuuming times per template.

To answer the objective questions, sample points were collected from areas classified on a scale of accessibility, and secondarily on a scale of surface porosity. This approach was designed by EPA and used during assessments of residential properties after the World Trade Center attacks:

1) **Accessible** areas refer to locations in the house that are readily accessible to residents on a routine basis. These areas are the most likely to be the locations of routine exposure, and are also the most likely to undergo routine cleaning.
   a) Porous surfaces (e.g., carpet, upholstered furniture, drapes, etc.)
   b) Non-porous surfaces (linoleum floors, hardwood floors, counter and table tops, window sills, etc.).

2) **Infrequently accessed** areas refer to locations that residents access only intermittently. These are areas where dust cleaning will be less frequent and where dust (and LA) may accumulate (i.e., tops of shelves, entertainment centers, and refrigerators, beneath furniture, inside cabinets, etc.).

3) **Inaccessible** areas refer to locations that residents access only on a very infrequent basis. These areas are likely to be cleaned very rarely, and hence may be locations where LA may have built up over an extended period of time (i.e., behind refrigerators or other large infrequently moved objects, inside forced air floor or ceiling vents, corners of closets, etc.).

To the extent possible, the sub-sample locations were collected from each type of accessibility area.

A total of 16 samples were collected from each of ten houses. These samples consisted of the following:

- <u>Accessible Target Areas (Porous Surfaces):</u> One (parent) sample and one field duplicate sample, each collected as a 12-point composite to represent frequently accessed areas with porous surfaces on the selected floor.

- <u>Accessible Target Areas (Non-Porous Surfaces)</u>: One (parent) sample and one field duplicate sample, each collected as a 12-point composite to represent frequently accessed areas of non-porous surfaces on the selected floor.

- Infrequent Target Areas: One (parent) sample and one field duplicate sample, each collected as a 12-point composite, to represent infrequently accessed areas on the selected floor.

- Inaccessible Target Areas: One (parent) sample and one field duplicate sample, each collected as a 6-point composite, to represent inaccessible areas on the selected floor. If six inaccessible sub-sample locations were not identified, the total number of subsamples was reduced as long as all available areas were included in the subsamples.

- Whole-Floor Composite (30-Second Sampling): One primary (parent) sample and one field duplicate sample, each a 30-point composite sample, collected from 30 templates placed in locations selected to represent the entire floor.

both vacuum samples using mini vac?

- Whole-Floor Composite (120-Second Sampling): One primary (parent) sample and one field duplicate sample, each a 30-point composite sample, will be collected as described above, except that each of the 30 templates will be collected using a vacuuming time of 120 seconds. The sampling locations for these templates were co-located with the template locations for the 30-second composites (above).

- High Traffic Areas: One primary (parent) sample and one field duplicate, each a 3-point composite, from high traffic areas on the selected floor. Each template in the 3- point composite sample was collected over 2 minutes according to the standard protocol (EPA 2003b).

- Horizontal Surfaces: One primary (parent) sample and one field duplicate sample, each a 3-point composite, from horizontal surfaces on the selected floor. Each template in the 3-point composite sample was collected over 2 minutes according to the standard protocol (EPA 2003b).

Each sub-sample point (template) was 100 $cm^2$ using disposable paper templates for measurement. The pilot study was completed using sampling procedures described in ASTM 5755-03 and CDM-LIBBY-10, *Project-Specific Guidance Document for the Collection of Dust Samples.*

In all cases where a composite sample were collected on more than one filter cassette, all cassettes with the same sample index ID number were combined at the laboratory during sample preparation and analyzed as one sample. All samples were analyzed by TEM ISO with a target sensitivity of 20 $cm^{-2}$.

Of the 160 samples collected as part of the dust pilot study, 154 were analyzed. After initial results were received and evaluated, EPA determined the data set for the 154 samples was adequate for data interpretation. Of the 154 samples analyzed, LA was detected in 25 (16.2 percent) samples at concentrations ranging from 6 to 77 s/$cm^2$. Of the 25 samples with detections, the parent sample and associated field duplicate had LA detections on both samples for only five (6.5 percent) of the 77 pairs analyzed. The low LA concentrations observed along with the inability to collect reproducible samples, resulted in EPA eliminating the collection of dust samples for property investigations as of July 2007. Although the dust pilot study samples are not stored in the project database, the analytical results are summarized during a preliminary review of the data by SRC and are presented in Table 2-1.

incorporate Summ. Report

## 2.13 Activity-Based Sampling

As discussed in Section 2.9.4, EPA collected initial data beginning in 2005 to evaluate human exposure to LA and the efficacy of cleanup activities. Although the data widely varied, a discernable correlation between elevated LA levels in soil (by PLM-VE) and elevated levels of LA in air was determined. While informative, these initial data were not sufficient to support reliable risk assessment or risk management decisions because of the following (EPA 2007b):

- Not enough samples were collected to adequately limit statistical uncertainty.
- Not enough samples were collected to ensure adequate spatial and temporal (seasonal) representativeness of the data.
- Scenario locations were stratified solely on the analytical results by PLM-VE and did not consider the presence of vermiculite in soil.
- The PLM-VE method, which has a practical quantitation limit of about 0.2 percent (weight) for LA, may not be sensitive enough to identify levels in soils that, when disturbed, generate asbestos levels in air that are of potential concern.

post cleanup ≡ 1) cleaned up 2) not sufficient level for trigger cleanup

Therefore, in 2007, EPA began collecting additional data to support risk management decisions and to further evaluate the efficacy and protectiveness of the cleanup strategy. The process of monitoring LA fiber releases during scripted activities is referred to as "activity-based sampling." The ABS program consisted of both indoor and outdoor sampling at properties where EPA had previously investigated LA sources and had either taken cleanup action or else determined that no cleanup action was needed under the current removal action protocol. In both circumstances, these properties are referred to as "post cleanup" throughout Section 2.13. The locations of participating properties in Indoor ABS, Outdoor ABS, or both programs are shown on Figure 2-21.

The primary ABS objective was to determine if remaining indoor and outdoor risks in post cleanup properties were within acceptable limits. EPA theorized that inhalation of air in the immediate vicinity of an active source disturbance was the most important exposure pathway for residents and workers at OU4. Personal air samples were collected instead of stationary air samples to more closely represent the breathing zone of individuals engaged in the scripted activities and more closely simulate the potential exposure of residents to LA. The secondary ABS objective was to collect representative data about characteristics of property contamination in order to develop a method for predicting indoor and outdoor air measurements at other properties at OU4 and help guide future removal decisions at the Libby Site. For this reason, dust and soil samples were also collected as part of the ABS program in an attempt to quantify LA concentrations in potential source materials that were disturbed during ABS. This section summarizes the rationale and procedures for ABS which is presented in the *Sampling and Analysis Plan for Activity-Based Indoor Air Exposures in Operable Unit 4* and *Sampling And Analysis Plan for Activity-Based Outdoor Air Exposures in Operable Unit 4* (EPA 2007b and EPA 2007c, respectively), which are provided in Appendix A.

## 2.13.1 Indoor Activity-Based Sampling

As discussed in greater detail in Section 2.20.2, indoor removal actions primarily consist of the removal of accessible vermiculite insulation from an attic or living space and the removal of contaminated dust. However, at post cleanup properties, several remaining sources of indoor contamination include the following:

- Releases from residual indoor sources remaining post cleanup:

  1) residual levels of vermiculite insulation or LA in areas not removed during the cleanup (e.g., including floor, carpets, upholstery, air ducts, etc.);
  2) vermiculite insulation remaining in walls; and
  3) trace levels of LA or vermiculite insulation in areas that were cleaned.

- Transfer of contaminated soil into the house. Vermiculite in non-specific use areas (NSUA) and soil samples with <1 percent LA remain at properties where a removal action has not taken place (as discussed further in Section 2.17). Vermiculite may also be present in NSUAs at properties where a removal action has been completed prior to 2007.

- Exchange of indoor and outdoor air through windows and ventilation systems.

- Transfer of contamination from sources outside the post cleanup property.

In order to more accurately represent long-term averages of indoor LA levels indoors and to represent the seasonal variability that may affect the releasability of LA fibers, Indoor ABS was repeated at each of 80 participating houses once a quarter over one year. The first Indoor ABS event began in July 2007 and the fourth Indoor ABS event ended in June 2008. The sections below summarize the process for property selection and sample collection.

### 2.13.1.1 Property Selection

Properties selected for Indoor ABS were grouped into two main categories: those where an outdoor removal action had been completed and those where an outdoor removal action was not warranted based on current removal criteria. Within each category there were additional criteria based the level and extent of residual LA contamination in outdoor soil and geographical representativeness.

Initial property selection was based on CSS findings combined with the removal action history of each location. However, due to the variations in soil sample collection and visual vermiculite inspection procedures of previous investigations, each potential property was re-inspected for outdoor vermiculite in May 2007 and two soil samples were collected. Analytical results were compiled with visual inspection results to stratify each property into one of four categories as shown in the table below.

| Category | Did Outdoor Soil Cleanup Take Place? | Post-cleanup Surface Soil | | |
|---|---|---|---|---|
| | | VCS | | PLM Detect |
| 1 | No | - | and | - |
| 2 | | + | or | + |
| 3 | Yes | - | and | - |
| 4 | | + | and | - |

Notes: VCS - vermiculite-containing soil; PLM - polarized light microscopy

In total, 94 potential properties were inspected for visible vermiculite and soil sampled, but only 81 properties progressed to the activity-based portion of the program to ensure an equal number of properties were sampled in each category from each geographical region of OU4 (north, central, south).

After the final set of properties was identified, data was collected through verbal interviews with homeowners to address other residual sources that may contribute to LA in indoor air in post-cleanup properties (e.g., carpets, upholstery, air ducts, and vermiculite insulation in walls). Information collected regarding residual sources was captured on the *ABS Property Background and Sampling Form*. In the event that LA levels in air exhibit trends particular to any specific contamination category, the information collected on residual sources may help determine potential modifications to the removal process.

### 2.13.1.2 Soil

As part of the property selection process mentioned above, two soil samples were collected from each potential Indoor ABS property. Each soil sample was a 30-point composite collected from the surface soil. One sample was collected from all SUAs (0 to 6 inches bgs) and one sample was collected from all NSUAs (0 to 3 inches bgs). Soil sampling characterized the property as a whole, and composite locations were selected at random without regard to previous excavations or analytical soil results. The visible vermiculite and LA data derived from the preliminary inspections provided characterization of residual outdoor soil levels to support the assessment of whether residual vermiculite-containing soil (VCS) or LA in outdoor soil poses a continuing source to indoor dust or air.

In addition to soil sample collection, the entire property was inspected for visible vermiculite at a maximum density of 1 point per 100 $ft^2$ as described in CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties, Revision 1*. Locations of visible vermiculite were documented on a *Visual Vermiculite Estimation Form* (VVEF) and annotated on a field sketch.

The soil samples were analyzed by PLM-VE and PLM-Grav, but one soil sample may have been analyzed multiple times, resulting in more analyses than samples collected. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 195 total soil samples.

| **Indoor ABS Soil Sample Results Summary** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Detection Frequency** | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 198 | 186 | 12 | - | - | - |
| | PLM-Grav | 122 | 122 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

### 2.13.1.3 Scripted Activities

While there are a wide variety of regular indoor activities, it was not the intent to collect data under every possible combination of activity and source disturbance. Rather, samples were representative of two generic conditions at each of the four categories of contamination:

- Active behaviors
- Passive behaviors

Active behaviors included a wide range of indoor activities in which a person is moving about the building and potentially disturbing indoor sources (i.e., walking, sitting down on upholstered chairs, sweeping, and/or vacuuming). During active sampling, the actor had the highest tendency to disturb source materials.

Passive behaviors involved very limited movement and simulated homeowner activities such as sitting and reading a book, watching television, or working at a desk. During passive sampling, the actor had the lowest tendency to disturb source materials.

During each of the quarterly sampling events, actors simulated active and passive behaviors during two separate 4-hour periods. In order to ensure that each 4-hour sample was spatially representative of the house, each sample was collected from all living spaces on each floor of the house. The total sampling time (4 hours) for each behavior (passive and active) was divided evenly among the total number of rooms in which routine living activities occur (i.e., smaller rooms such as closets, utility rooms, bathrooms were not included). The time spent per room was then equally subdivided among the number of activities to perform depending on site conditions.

In situations where the homeowner could not devote two 4-hour periods on consecutive days, sampling was performed over one 8-hour time interval where the passive behavior was performed first. For the majority of properties, sampling was conducted over two consecutive days and the sequence of passive and active behavior simulations was randomized between quarterly sampling events.

### 2.13.1.4 Air

Two personal air samples were collected during each 4-hour sampling period, one to serve as a backup in case the other failed, was damaged, or was lost. The target flow rates for sample collection were 10 and 3 L/min resulting in target volumes of 2,400 and 720 L, respectively. Each air sample was collected on 0.8 μm, 25 mm MCE filter and the cassette was oriented face down in the breathing zone of each actor.

As mentioned above, 81 properties were initially included in Event 1 so that a full set of 80 properties could continue in the program if one homeowner withdrew from the year-long commitment. Air samples with the highest volume were analyzed by TEM ISO with a target sensitivity of 0.0002 $cc^{-1}$, while the lower volume sample was archived. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 642 analyzed air samples.

| Indoor ABS Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | |
| Sample Type | Analytical Method | Number of Analyses | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Personal Air | TEM ISO | 642 | 396 | 246 | 1 – 50 | 0.00013 – 0.04976 s/cc |

Notes: s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; LA – Libby Amphibole

### 2.13.1.5 Dust

Data on pre-cleanup indoor dust levels were collected at each cleanup property as part of the CSS or PDI prior to 2007, but post-cleanup dust samples were not collected, even when an indoor dust cleanup occurs. Therefore, to characterize residual contamination in dust and potentially correlate indoor air results with indoor dust, dust samples were collected before scripted behaviors were performed for each quarterly sampling event. Dust samples were composited across all rooms where routine activities occur. Dust samples were collected using a microvacuum technique and consisted of ten composited locations (four accessible areas, four infrequently accessed areas, and two inaccessible areas) as described in CDM-LIBBY-10, *Project-Specific Guidance Document for the Collection of Dust Samples, Revision 1.*

sensitivity?

All dust samples were analyzed by TEM ISO with a target sensitivity of 20 $cm^{-2}$. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 337 analyzed dust samples.

| Indoor ABS Dust Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Dust | TEM ISO | 337 | 327 | 10 | 1 – 4 | 6 – 79 s/$cm^2$ |

Notes: s/$cm^2$ – structures per square centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; LA – Libby Amphibole

## 2.13.2 Outdoor Activity-Based Sampling

As discussed in greater detail in Section 2.20.3, outdoor removal actions consist of the removal of vermiculite in SUAs, removal of soil with analytical results ≥1 percent, and removal of soil with analytical results <1 percent only if an additional removal trigger is met at the property. At post cleanup properties, the potential sources of outdoor contamination remaining are:

- Vermiculite in NSUAs and soil samples with <1 percent LA remaining at properties where the removal criteria were not met (as discussed in Section 2.17).
- Vermiculite remaining in NSUAs at properties where a removal action was completed prior to 2007.
- Transfer of contamination from sources outside the post cleanup property.

In order to more accurately represent long-term health risks from exposure to LA in outdoor air near disturbed soil and to represent the seasonal variability that may affect the releasability of LA fibers, Outdoor ABS was repeated at each of 75 scenario areas in Summer 2007 and Spring 2008. Separate moisture restrictions (i.e., field moisture deficiency, rainfall totals) were established for both sampling events to ensure sampling conditions were representative of the season and not biased low. Portable weather stations were set up at each property to monitor onsite meteorological conditions (i.e., wind speed, wind direction, relative humidity, temperature, and barometric pressure).

The sections below summarize the process for property selection and sample collection.

#### 2.13.2.1 Property Selection

Properties for Outdoor ABS were selected based on the level and extent of residual LA contamination in outdoor soils and geographical representativeness. Historical soil sample results were used to identify known areas of contamination, and areas of clean fill were used as a point of reference against other categories of soil. Soil sample collection was not a component of Outdoor ABS property selection. Given the current protocol for removal actions at a property, yards (or sub-parts of yards) at post-cleanup properties were categorized into five types, as follows:

| Soil Category | Residual Source | |
|---|---|---|
| | PLM-VE Analysis for LA | Visual Presence of Vermiculite |
| 1 | None (clean fill has been added) | |
| 2 | Bin A (non-detect) | No |
| 3 | Bin A (non-detect) | Yes |
| 4 | Bin B1 (<0.2%) | Either Yes or No |
| 5 | Bin B2 (0.2% - 1%) | Either Yes or No |

Notes: PLM-VE - polarized light microscopy-visual area estimation; LA – Libby Amphibole;
< - less than; % - percent

Whenever possible, locations for Outdoor ABS testing were selected from post-cleanup properties. However, because an adequate number of sampling locations representing each soil category could not be identified, sub-parts of yards (or scenario areas) meeting the contamination characteristics were identified in properties where a removal action was required. These 23 properties were temporarily removed from the 2007-2008 removal queue to ensure a complete dataset could be collected for Outdoor ABS.

In total, 75 scenario areas at 62 properties were identified that equally represented the soil contamination categories and each geographical region of OU4 (i.e., north, central, south). Of the 62 properties, 39 were classified as post cleanup and only the sub-parts of the remaining properties that were post cleanup were used for Outdoor ABS. Additionally, a single Outdoor ABS property could satisfy multiple contamination categories in different sub-parts of the yard.

#### 2.13.2.2 Scripted Activities

While there are a wide variety of regular outdoor activities, it was not the intent to collect data under every possible combination of activity and source disturbance. Rather, samples were representative of three standardized activities at each of the five categories of contamination. Each activity was considered a realistic example of relatively vigorous disturbances:

- Raking the lawn or yard with a metal-tined leaf rake
- Digging in the soil with a shovel and pail (simulating a child's play)
- Mowing the yard with a gasoline powered rotary lawn mover

During each of the two sampling events, actors simulated the three activities during separate 2-hour periods at each scenario area. Activities were performed in the same sequence of raking, digging, and mowing. At properties where multiple soil categories were present (e.g., sub-parts of yard with clean fill as well as sub-parts of yard with visual vermiculite that were sampled non-detect by PLM) the scenario area with the lowest anticipated contamination was tested first. Additionally, Indoor and Outdoor ABS were conducted on separate days if the homeowner participated in both programs.

### 2.13.2.3 Air

Two personal air samples were collected during each 2-hour sampling period, one to serve as a backup in case the other failed, was damaged, or was lost. The target flow rates for sample collection were 10 and 3 L/min resulting in target volumes of 1,200 and 360 L, respectively. Each air sample was collected on 0.8 µm, 25 mm MCE filter and the cassette was oriented face down in the breathing zone of the actor.

Air samples with the highest volume were analyzed by TEM ISO with a target sensitivity of 0.001 $cc^{-1}$, while the lower volume sample was archived. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 460 analyzed air samples.

| Outdoor ABS Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | |
| Sample Type | Analytical Method | Number of Analyses | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Personal Air | TEM ISO | 460 | 141 | 318 | 1 – 64 | 0.00046 – 57.906 s/cc |

Notes: s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; LA – Libby Amphibole

### 2.13.2.4 Soil

Before scripted behaviors were performed in each sampling event, one soil sample was collected from each scenario area to characterize residual soil contamination and correlate outdoor air results with outdoor soil. One 30-point composite soil sample was collected from the surface soil of each scenario area in accordance with CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection, Revision* 2. Each soil sample was analyzed for both LA and water content, and therefore water was not used during sample collection for dust suppression.

In addition to soil sample collection, each scenario area was inspected for visible vermiculite in accordance with CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties, Revision* 1. Locations of visible vermiculite annotated on a field sketch.

During the second Outdoor ABS event (Spring 2008), an additional soil sample was collected at each scenario area from the two digging sub-locations. These composited samples were collected from the surface soil and followed the collection and visual inspection protocols referenced above.

The soil samples were analyzed by PLM-VE and PLM-Grav, but one soil sample may have been analyzed multiple times, resulting in more analyses than samples collected. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 237 total soil samples.

**Outdoor ABS Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 272 | 186 | 67 | - | 17 | 3 |
| | PLM-Grav | 38 | 38 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

At the completion of the Outdoor ABS program, the 23 properties meeting removal criteria were added back to the removal queue and 17 have been completed to date.

### 2.13.2.5 Soil Condition Data

It was expected that the amount of dust (and asbestos) released from an ABS event depended in part on the condition of the soil at the time of the ABS event. In order to help characterize this source of variability, and potentially to allow for some degree of normalization between locations, the following data items were collected for each scenario area:

- Nature and extent of soil vegetative cover
- RAMs set up in the immediate proximity of the ABS disturbance to measure dust levels in air
- Soil moisture
- Soil texture

### 2.13.2.6 Experimental ABS Air Samples

In June 2008, EPA's Office of Research and Development (ORD) selected four Outdoor ABS properties for studying the releasable asbestos field sampler (RAFS) unit at areas with presumably low concentrations of LA. Historically, the four properties had no detectable levels of LA in soil by PLM-VE but had localized areas of visible vermiculite. Air samples were collected by EPA ORD within 24 hours of Outdoor ABS in accordance with the *Quality Assurance Project Plan: Phase 2 - Evaluation of the Aerosolization of Asbestos and Related Fibers from Bulk Materials* (EPA

2009d). In total, 24 air samples were analyzed by TEM ISO, and analytical results for all samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

### 2.13.3 Findings of Activity-Based Sampling

Although a summary report of the ABS programs is still in development, several preliminary conclusions suggest the following:

- Visible vermiculite may be a more reliable indicator of LA than previously anticipated.
- LA detections in indoor and outdoor air tend to be highest in summer months.
- LA detected in areas of clean fill suggest either a source of recontamination or a level of LA in soil unaffiliated with historic mine operations. — or didn't remove it all in first place
- Dust samples did not appear to be a reliable indicator of LA in indoor air.

Once the summary report is finalized, the conclusions will be included in a future version of this report.

## 2.14 Libby Background Soil Study

In order to investigate geologic factors that could have contributed to low levels of LA in background soils, a geological investigation of sources and levels of LA in the Libby valley was conducted in June 2008 in accordance with the *Study Design to Pilot Reconnaissance Activities for the Characterization of Geological Sources of Libby Amphibole in Libby Valley Soils* (EPA 2008b) which is included in Appendix A.

As discussed in Section 2.17, when LA levels exceed EPA's current removal criteria, the contaminated soils are removed and replaced with clean fill collected from borrow pits (Section 2.5.18). However, the analytical results for the 2007-2008 outdoor ABS program (Section 2.13.2) indicated that LA continues to be detected in air at locations of clean fill material in which LA was not detected by PLM-VE and where no vermiculite was identified during visual soil inspection. It was not known whether these structures are attributable to unrecognized anthropogenic sources, such as historic mining activities or recontamination, or whether the fibers are geologic in origin. The samples collected as part of the background study were collected to characterize LA in soils not previously identified as being affected by anthropogenic activities (e.g., mining). The soils are considered to represent the background and address the low-level or background exposure at the Libby Site (EPA 2008b).

Soil samples for the background study were collected from three borrow sources within the Libby valley (Figure 2-20). EPA has derived clean fill material for use in cleanup activities at one of the three selected locations (Remp's Pit). USGS selected specific sampling locations and soil horizons based on a review of geologic maps, literature, field observations and professional judgment. Samples were in accordance with CDM-LIBBY-15, *Project-specific SOP of Fine-Grained and Course-Grained Soil Sample Preparation for Soils Collected From Borrow Pits.*

At each borrow source, the number and location of samples was determined in the field based on a consideration of the visible geology. Typically, the vertical face at each area was cleaned of loose debris, and the USGS technical lead inspected the face and identified strata representing different ages and different modes of formation.

All soil samples selected for analysis were analyzed by scanning electron microscopy (SEM) in accordance with SRC-LIBBY-02, *Reflectance Spectroscopy Screening for Asbestos in Soil, Revision 2* and incorporating requirements as specified in LB-000066. A total of 74 field samples were collected from three study locations during this phase of the background study.

The results of these samples and conclusions of the background study were not available at the time of this report, but will be included in a future version as additional information becomes available. Additional components of this study are planned for the future to further evaluate the background level of LA in the Libby valley and will also be included in this report as information becomes available.

## 2.15 School Investigation

In June 2008, the five current public schools in Libby were inspected for visible vermiculite products and a limited number of outdoor soil samples were collected. The objectives of these inspections were to: 1) identify sources or exposure pathways within the indoor and outdoor portions of the school buildings; 2) delineate each school into preliminary sampling zones based on shared airspaces and usage; and to 3) conduct outdoor inspections in areas of new construction and/or soil disturbances. All work was conducted in accordance with the *Final Technical Memorandum, Libby Public School Inspection, Libby, Montana* (CDM 2008c) which is provided in Appendix A.

The inspections focused on identifying and documenting the location of vermiculite or vermiculite insulation within the buildings; checking open walls, ceilings, and floor penetrations for vermiculite insulation or vermiculite-containing building materials (VCBM); and inspecting outdoor walls and perimeter soils for vermiculite or vermiculite insulation. A detailed summary of the June 2008 school inspections, including figures illustrating the air zones and locations of source materials are available in *Libby Schools Visual Vermiculite Investigation Summary* (CDM 2008d) which is provided in Appendix A.

### 2.15.1 Kootenai Valley Head Start (formerly Plummer Elementary)

Moderate levels of vermiculite were identified in two 5-gallon buckets of sand in a storage room south of the main gym area. One of the buckets had three toy shovels in it and a small quantity of this sand had spilled on the floor nearby. Low levels of vermiculite were also observed in the soil of a houseplant in the northwest office. Vermiculite was not observed on the exterior of the building during the inspection.

### 2.15.2 Libby Elementary School (formerly Asa Wood Elementary)

Vermiculite or vermiculite insulation was not observed during the indoor and outdoor perimeter inspection even though the cinderblock walls are known to contain vermiculite insulation. VCBM was identified in the form of wall plaster in the east wing and wall plaster at the north side of the stage. The plaster in both locations was in good condition and not friable.

In addition to the indoor and outdoor perimeter inspection, 18 composite surface soil samples were collected along the walking path and from the recently constructed playground in accordance with CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection, Revision 2*. The 30-point composite samples were ranged in depths from 0 to 6 inches bgs.

Inspection for vermiculite was performed during sample collection and was also performed in areas of the school with previously detected levels of LA. Visual inspection was performed in accordance with CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soil, Revision 1*. Low levels of vermiculite were observed in five of the soil sample locations and one of the areas with previously detected concentrations of LA. A detailed summary of this sample collection event, as well as the location of analytical and visual inspection results can be found in *Libby Schools Visual Vermiculite Investigation Summary* (CDM 2008d).

The soil samples were analyzed by PLM-VE and PLM-Grav, but one soil sample may have been analyzed multiple times, resulting in more analyses than samples collected. Analytical results of two samples collected along the walking path detected LA at trace concentrations and the remaining samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the 22 total soil samples:

**Libby Elementary School Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 25 | 23 | 2 | - | - | - |
| | PLM-Grav | 2 | 2 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

### 2.15.3 Libby Middle School

Vermiculite was observed in two locations in the Yellow Wing of the school. One piece of vermiculite was identified underneath a sink and subsequently disposed of as investigation-derived waste (IDW). A potential source for the material could not be identified. Vermiculite was also identified in a plastic planter pot in one of the classrooms.

An outdoor inspection for vermiculite was performed in areas of new construction (e.g., water line installation) and during a scheduled excavation to repair a sprinkler on the football field. Soil samples were not collected due to the limited size of the areas and observation of only one flake of vermiculite. Visual inspection was performed in accordance with CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soil, Revision 1.*

Following the June inspection, EPA was contacted by a resident who identified vermiculite within the playground east of the school that was not part of the initial inspection. Four composite surface soil samples were collected from the playground areas, the amphitheater, and a recently excavated area where vermiculite was observed. The 30-point composite samples ranged in depths from 0 to 6 inches bgs and were collected in accordance with CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection, Revision 2.*

Soil samples were analyzed by PLM-VE and PLM-Grav. Analytical results for all samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

Below is a summary of the results by analytical method and LA detection frequency for the four total soil samples:

**Libby Middle School Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 4 | 4 | - | - | - | - |
| | PLM-Grav | 1 | 1 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

### 2.15.4 Libby High School

Vermiculite was observed beneath the wood floors in the two greenhouses, in several plastic flowerpots, and two flakes were observed in outside soils at the northeast corner of the building.

The removal action which addressed the soil contamination at Libby High School is discussed in Section 2.21.1.

### 2.15.5 Libby School District Administration Building

Vermiculite was not observed in the interior or the exterior of the building. However, VCBM was identified in the form of wall plaster located in the second floor storage room. The plaster was in good condition and not friable.

### 2.15.6 Stationary Air

Based on the air zones delineated during the June 2008 school inspections, an indoor air SAP was developed for the public schools. Delineation of the air sampling zones considered the following general elements:

1) Whether a given area is populated primarily by students (e.g., classrooms) or faculty (e.g., administrative offices)

2) Physical features such as fire breaks or building wings

3) Room or area usage (e.g., metal shop vs. classroom)

4) Ceiling height (e.g., auditorium or gym vs. classrooms)

5) Other factors that could affect sample results including, but not necessarily limited to, the presence of sprayed on fireproofing, possible presence of VCBMs, dusty conditions (e.g., in a wood shop), etc.

The purpose of the sampling event was to collect indoor stationary air samples to support the assessment of LA concentrations in the air at the public schools in Libby. Sampling was conducted during normal school hours and was intended to be representative of typical indoor conditions at each school.

In December 2008, a total of 51 stationary samples were collected in accordance with the *Final Sampling and Analysis Plan for Libby Public Schools – Stationary Air Sample Collection* (CDM 2008e) which is provided in Appendix A. Five air samples were collected from each school over two consecutive school days. The sampling cassettes were placed at a level corresponding to the breathing zone of the students in the room for each sampling location. Additionally, sample collection was suspended during extended periods of inactivity. The target flow rate for sample collection was 10 L/min resulting in target volumes from 2,400 to 9,600 L depending on the level of student use over the course of the two day period.

All air samples were analyzed by TEM ISO with a target sensitivity of 0.0006 $cc^{-1}$. Analytical results for two samples had detectable levels of LA ranging from 0.00051 to 0.00059 s/cc, while the remaining 49 samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results. A detailed summary of the December 2008 air sample collection is available in the *Libby Public Schools - Stationary Air Sampling Investigation Summary* (CDM 2009d) which is provided in Appendix A.

The table below summarizes the results by analytical method and LA detection frequency for the 51 analyzed air samples.

| Indoor ABS Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | |
| Sample Type | Analytical Method | Number of Analyses | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Stationary Air | TEM ISO | 51 | 49 | 2 | 1 | 0.00051 – 0.00059 s/cc |

Notes: s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; LA – Libby Amphibole

## 2.16 School Activity-Based Sampling

In July 2009, EPA began collecting additional data to support risk management decisions and to further evaluate the protectiveness of the cleanup strategy specific to the public schools in Libby. ABS was selected to characterize exposures of students and staff to asbestos during routine outdoor activities that disturb outdoor soil at schools. This section summarizes the rationale and procedures for ABS which is presented in the *Final Sampling and Analysis Plan for Activity-Based Outdoor Air Exposures at Libby Public Schools* (CDM 2009e) which is provided in Appendix A.

There are a number of schools in Libby where portions of the grounds have been contaminated with vermiculite or other LA-containing mine waste. Although much of this outdoor contamination has been removed, limited data was available to evaluate whether the cleanups that have been performed are sufficient to provide adequate health protection to students and staff at the schools. Therefore, the primary ABS objective was to collect data of sufficient representativeness and quality to evaluate any potential exposures and inhalation risk from LA when outdoor soils are disturbed at Libby schools under present site conditions.

In order to more accurately represent long-term health risks from exposure to LA in outdoor air near disturbed soil, ABS at the schools was repeated three times at each of the five schools. Sampling was conducted from July to September 2009 to represent the hottest, driest period of the year and potentially eliminate the need to additional sampling during other seasons. Similar to the Outdoor ABS conducted at residential properties at OU4, moisture restrictions were established (i.e., field moisture deficiency, rainfall totals) to ensure sampling conditions were representative of the season and not biased low.

### 2.16.1 Scripted Behaviors

In general, the maintenance workers interact with the school grounds on a larger scale while the students have more localized interaction. Scenario areas for student activities were selected based on interviews conducted with the school administrators that determined the most heavily used areas. Two areas were selected at each school for conducting student scenarios, and the majority of maintenance worker scenarios were conducted across the school grounds.

Release of LA from soil was expected to be influenced by the nature of the soil disturbance activity that occurs. Because the purpose of this assessment was to characterize releases associated with both students and maintenance workers, the activities and behaviors that were used to disturb the soil were selected to be generally representative of the wide range of different activities these receptors might engage in. These activities were selected to be representative of average to high-end disturbances that students and workers may experience. In most cases, the student and maintenance worker scenarios consist of multiple activities and therefore the potential exposure of a specific activity was not evaluated.

- Students playing soccer, football, baseball, and Frisbee®
- Students swinging on a swing set
- Students running over various ground materials (i.e., playground, field, sand)
- Workers digging, raking, and mowing various ground materials (e.g., playground, field, sand), and sweeping hard surfaces

## 2.16.2 Air

Personal air samples were collected over a 2-hour time interval, which was subdivided by the number of representative activities per school. Each air sample was collected on 0.8 µm, 25 mm MCE filters and the cassette was oriented face down. Additionally, the heights of the cassettes were adjusted based on the average height of the intended receptor for each activity.

Only a high volume sample?

During each of the student scenarios, one personal air sample was collected from each of three participants to more closely represent children interacting in groups. The target flow rate for sample collection was 10 L/min, resulting in a target volume of 1,200 L.

During each of the maintenance worker scenarios, one participant performed the scripted activities while collecting two personal air samples at two flow rates. The target flow rates for sample collection were 10 and 3 L/min resulting in target volumes of 1,200 and 360 L, respectively.

One of the three student air samples and the maintenance worker air samples with the highest volume were analyzed by TEM ISO with a target sensitivity of 0.003 $cc^{-1}$. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 64 analyzed air samples.

School repeal samps 63

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| School ABS Air Sample Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | **Detection Frequency** | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | Number of ND Samples | Number of Detects | Range of Total Number LA Structures | Concentration Range of Detections |
| Personal Air | TEM ISO | 64 | 59 | 5 | 1 | 0.00223 – 0.03885 s/cc |

63 ?

Notes: s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; ISO – International Organization of Standardization; LA – Libby Amphibole

## 2.16.3 Soil

One 30-point composite soil sample was collected from each scenario area during the first and third of the three sampling events to characterize residual soil contamination and correlate outdoor air results with outdoor soil. Scenario areas that were covered by asphalt, concrete, or gravel (without fine-grained soil) were not sampled. Due to the large extent of many schools, composite locations were only collected from those areas not previously included in the smaller subareas (i.e., a school-wide soil sample would not contain the same composite point locations as the soil sample collected from soccer field). Additionally, one soil sample was composited from each of the digging activity locations for each sampling event. All soil samples were collected in accordance with CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection, Revision 2.*

In addition to soil sample collection, each scenario areas was inspected for visible vermiculite in accordance with CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimate of Vermiculite in Soil, Revision 1.*

The soil samples were analyzed by PLM-VE and PLM-Grav, but one soil sample may have been analyzed multiple times, resulting in more analyses than samples collected. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 44 total soil samples.

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Don't match ~~math~~ the School report counted more than once ?

| School ABS Soil Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Detection Frequency** | | | | |
| **Sample Type** | **Analytical Method** | **Number of Analyses** | **Bin A ND** | **Bin B1 TR** | **Bin B <1%** | **Bin B2 <1%** | **Bin C ≥1%** |
| Surface | PLM-VE | 49 | 15 | 34 | - | - | - |
| | PLM-Grav | 20 | 20 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

What about visible detects ?

### 2.16.4 Soil Condition Data

It was expected that the amount of dust (and asbestos) released from an ABS event depended in part on the condition of the soil at the time of the ABS event.

The amount of LA released from an ABS event depends on both the level of contamination in the soil and the condition of the soil at the time of the ABS event. Therefore, the following data items will need to be collected:

- The level of LA and/or vermiculite in soil within the ABS scenario area, as measured by PLM-VE and visual inspection
- Nature and extent of soil vegetative cover
- Soil moisture
- Soil texture

### 2.16.5 Experimental ABS Air Samples

In August 2009, EPA ORD returned to the Libby Site for continued testing of the RAFS unit in grass covered areas and hard surfaces (e.g., parking lot, sidewalks). Analytical results of the air and soil samples collected to support this research is not available in the project database.

## 2.17 Remediation Status

As emphasized in the previous sections, the general goal of the sampling investigations at OU4 was to provide information about the presence of LA source materials at individual properties. Based upon that information, as well as the cleanup triggers specified in the *Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum* (EPA 2003c), EPA is able to classify each property as requiring remediation, may require remediation (i.e., more information needed) or not likely requiring remediation. This section discusses the remediation status query (RSQ), which serves as a basis for classifying properties and aids in PDI planning when remediation is required.

### 2.17.1 Removal Action Decision Criteria

Each property at OU4 may require cleanup in three general areas: the attic space, the indoor living space, and outdoors. Therefore, three decisions are required for each property to determine the need for, and extent of, cleanup. Generally, investigative results from each of these areas are treated separately. That is, results may trigger cleanup in one area (e.g., attic space), but not others.

Removal action levels were established in the *Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum* (EPA 2003c) which is provided in Appendix A. The table below outlines the current residential/commercial property cleanup action level trigger(s) for each area. For each area, a property has to meet only one of the triggering action levels (as opposed to all) for cleanup to be required in that area. Again, it is important to note that cleanup criteria and action levels are subject to change and have been continually evaluated throughout EPA's processes. Final action levels, and the total number of properties requiring cleanup, will be available after the RI/FS is completed and a Record of Decision is published.

| Action Required | Location | Action Level Trigger |
|---|---|---|
| | **Indoor** | |
| | Attic/Walls | Visual confirmation of open, non-contained, or migrating vermiculite insulation |
| | Living Space | 1) Visual confirmation of vermiculite in the indoor living space<br>2) Dust sample with LA concentration greater than or equal to 5,000 s/cm$^{2}$* |
| | **Outdoor** | |
| | SUAs | 1) Visual confirmation of vermiculite or other vermiculite-related waste products<br>2) Soil sample result greater than or equal to 1% LA by PLM |
| | NSUAs** | Soil sample result greater than or equal to 1% LA by PLM |
| **No Current Action** | All locations | None of the above conditions are present at the property |

Notes: *if dust samples were collected before 2007; **beginning in 2007, if one or more removal triggers exist at a property, visible vermiculite in NSUAs is also removed; SUA – specific use area; NSUA – non-specific use area; % - percent; LA – Libby amphibole; PLM – polarized light microscopy

For those properties requiring removal actions, EPA has adopted additional cleanup procedures and criteria that will that help ensure only one cleanup action is conducted at individual properties. For instance, soils with detectable levels of LA <1 percent are removed from a property if any of the removal triggers listed above are present. Additionally, in 2007, visible vermiculite in NSUAs was also identified for removal if remediation was required at the property for other sources of contamination.

### 2.17.2 The Remediation Status Query

The RSQ compiles the electronic IFF data and analytical results from dust and soil samples in order to assign a remediation status to each property based on the removal action level triggers presented in the table above. For the purpose of the RSQ, a property is defined as an address or group of addresses that will be treated as a single property group (e.g., apartment buildings, properties containing a residence and business or multiple businesses within the same building). In the RSQ, a property group is classified as requiring action if, at a minimum, one or more removal action level triggers are met. A property is classified as not requiring action if none of the above criteria are met or if insufficient data are available for proper classification. A property is classified as needing more information when potential exposure pathways are present but no removal action triggers are met. The potential exposure pathway criteria still being evaluated by EPA are:

- Vermiculite in a NSUA
- Soil sample results <1 percent LA
- Coarse fraction soil sample result by PLM-Grav ≥1 percent LA

- Secondary Indicators:
  - Former miner history
  - Knowledge of asbestos-related disease in family
  - Past vermiculite insulation in attic
  - VCBM
  - Vermiculite in walls
  - Vermiculite in understructures (e.g., crawlspaces)

As mentioned above, the RSQ uses a series of business rules that were developed around the 2003 EPA cleanup action level triggers. As such, the RSQ does not account for the following conditions at properties, and may need to be re-evaluated as a planning tool or modified when final cleanup action level triggers are established:

- Visible vermiculite in newly-defined SUAs (e.g., driveways)
- Visible vermiculite in NSUAs identified during recent supplemental investigations (e.g., ABS)

The RSQ was developed with the primary objective of compiling property-specific contamination and aiding in property selection for the removal design program. Most properties requiring remediation have followed the routine process from CSS to PDI and ending with a single removal action. However, once a property was identified as requiring removal, an emphasis was not placed on retroactively updating information about property contamination that arose at the design stage. An example of this is when a property is selected for a PDI due to vermiculite in the attic as noted on the IFF. When vermiculite is identified in additional areas, the additional areas are addressed during the removal but are not updated in RSQ.

### 2.17.3 Numbers of Properties

As shown on Figure 2-22, as of December 2009, 3,628 OU4 properties have been investigated. Based on the three removal planning categories and the criteria outlined in the table at the beginning of Section 2.17:

- 1,735 total properties were categorized as Requiring Cleanup (i.e., exhibited at least one current removal action level trigger) in an indoor or outdoor location of concern.
- 776 properties were categorized as Additional Information Needed (i.e., conditions suggest potential contamination, but did not meet the current removal action levels). The 776 properties generally fall into the following subcategories: 248 properties have trace or <1 percent LA in soil; 432 properties have secondary

indicators; 95 properties have visible vermiculite in a NSUA; and 1 property has a course fraction soil sample result $\geq$1 percent LA.

- 1,117 were categorized as Cleanup Not Likely Required (i.e., no emergency response triggers or other conditions suggesting contamination was observed or detected).

The location and remediation status of these properties are shown on Figure 2-23. These numbers are based on the visual presence of vermiculite in an attic, living space, SUA or NSUA as documented on the IFF during the CSS and combined with the analytical results for soil and dust samples collected during Phase 1, CSS, Post Cleanup Evaluation, SQAPP, PDI, and residential ABS. It is important to reiterate that prior to Fall 2006, no formalized approach to inspect or quantify vermiculite in soil existed.

## 2.18 Pre-Design Inspections

The PDI program began in 2003 and was the process for characterizing properties before a removal action. The objective of the PDI program was to expand on previously collected data in order to more precisely locate and quantify the contamination at each property. PDI activities included the collection of additional soil, bulk, and/or dust samples, the inspection of attics, soil and building materials for vermiculite, and the production of sketches, measurements, and relevant construction information. The *Exterior Inspection Checklist* (EIC) and *Supplemental Interior Inspection Checklist* (SIIC) forms were developed to standardize the property information collected during a PDI. The information and samples gathered were then used to fully characterize the property against established removal criteria. Following this process, a property-specific removal plan was created which specified the types of removal actions needed at the property.

PDI field activities were performed in accordance with the *Final Draft Pre-Design Inspection Activities Work Plan* (CDM 2003g) with modifications, which is provided in Appendix A. Approximately 1,400 properties within OU4 have been characterized to date through the PDI process.

### 2.18.1 Soil

***Land Use Area Designations***

Similar to the CSS soil inspection process, PDIs divide the outdoor soils into land use areas for vermiculite inspection and soil sampling. In general, properties are divided into SUAs, NSUAs, and non use areas (i.e., wooded or unmaintained areas). SUAs were defined as areas most likely to have received vermiculite products, undergo frequent or intense disturbances at the subsurface, and are not generally covered by grass. NSUAs were defined as areas with more generalized homeowner use and where it is less likely to encounter soil disturbances.

Prior to the 2007 field season, SUAs included current or former flowerbeds, current or former gardens, planters, stockpiles, and play areas. NSUAs included yards, driveways and fields. Beginning in 2007, driveways were reclassified as SUAs. Basis?

Prior to Fall 2006, outdoor soils were inspected for vermiculite during soil sample collection and to generally characterize each land use area where soil samples were not collected. In October 2006, a formal and systematic approach for vermiculite inspection was implemented with CDM-LIBBY-06, *Site-specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soil*. In general, one visual inspection point (for vermiculite) was performed per 100 $ft^2$ within each use area. Locations and quantities of vermiculite were documented on *Supplemental Exterior Inspection Checklists* (SEICs). In 2007, the visual vermiculite SOP was revised to require a lower inspection point density in areas with less use (e.g., limited use areas such as field, pasture). Additionally, the SEIC form was renamed to VVEF in order to increase usability of the form by other field programs.

***Soil Sample Collection***

Similar to the 2002 CSS field activities, 2003 through 2006 PDI soil samples were collected in accordance with the most recent version of CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection*. However, previous soil sampling efforts (Phase 1 and CSS) covered areas as large as 5,500 $ft^2$. In order to further delineate areas of excavation for removal actions, PDI soil samples were collected from areas no larger than 2,500 $ft^2$ and consisted of 5-point composite soil samples. SUAs containing vermiculite and areas with vermiculite tailings were not sampled as these areas were identified for removal.

Beginning in April 2006, SUAs containing vermiculite were sampled during the PDI, although a combination of visual vermiculite content and analytical results were used in determining their status for removal.

In 2007, the following changes to soil sampling procedures were implemented:

- April 2007 - Soil samples were not collected from SUAs, where vermiculite was present as these areas were identified for removal.

- May 2007 - PDI soil sampling changed from 5- to 30-point composite samples.

- May 2007 - Driveways were considered SUAs during property characterization, based on the similar nature and frequency of use to other SUAs.

- June 2007 - Soil samples were not collected from any areas where vermiculite was observed as these areas were identified for removal.

In total, 8,455 soil samples have been collected during PDI activities at 810 properties. The majority of samples collected have been 5- or 30-point composite surface soil samples, but a limited number of grab surface samples and subsurface soil samples have also been collected in preparation for removal actions. The following table summarizes the soil sample results:

**PDI Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 27 | 14 | - | 8 | - | 5 |
| | PLM-VE | 6,294 | 4,863 | 1,265 | - | 130 | 36 |
| | PLM-Grav | 2,115 | 2,110 | 4 | - | 1 | - |
| Subsurface | PLM-9002 | 1 | 1 | - | - | - | - |
| | PLM-VE | 5 | 1 | 3 | - | 1 | - |
| | PLM-Grav | 3 | 3 | - | - | - | - |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method

## 2.18.2 Dust

Microvacuum dust samples for PDI activities were collected in accordance with ASTM D5755 with modifications as described in *Final Dust Sampling Protocol for Pre-Design Investigations* (CDM 2003h) which is similar to the 2003 CSS dust sampling procedures and provided in Appendix A. Dust samples collected during the PDI were mainly collected from outbuildings on the property, but also included areas not previously characterized during the CSS (Section 2.4.2). At the request of EPA, based on conclusions from the dust pilot study (Section 2.12), PDI dust samples were no longer collected after July 2007.

In total, 3,810 indoor dust samples were collected during PDI activities at 526 properties. These samples were analyzed by TEM AHERA and TEM ISO with a target sensitivity of 500 $cm^{-2}$. Samples with analytical sensitivities greater than 1,000 $cm^{-2}$ were used for removal decisions only on a case-by-case basis. Refer to Appendix C for additional information on individual sample details and analytical results.

Summary information for the dust results is as follows:

**PDI Dust Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | LA Detection Frequency | | | |
|---|---|---|---|---|---|---|
| | | | Number of ND Samples | Number of Detects | Range of Number of Total LA Structures | Concentration Range of Detections |
| Indoor | TEM ISO | 511 | 493 | 18 | 1 – 22 | 146 – 5,853 s/$cm^2$ |
| | TEM AHERA | 3,304 | 3,086 | 1 | 1 – 56 | 30 – 113,224 s/$cm^2$ |

Notes: LA – Libby Amphibole; ND – nondetect; TEM – transmission electron microscopy; ISO – International Organization of Standardization 10312 method; AHERA – Asbestos Hazard Emergency Response Act; s/$cm^2$ – structures per square centimeter

### 2.18.3 Bulk Materials

PDI bulk samples were generally collected from friable building materials containing or suspected of containing vermiculite and/or LA (e.g., plaster, chinking, mortar, pipe wrap). VCBM bulk samples were collected in accordance with 40 CFR Part 763.86, Appendix C - *AHERA Sampling Requirements*. This CFR sampling procedure specifies how many subsamples must be collected per homogeneous sampling area.

A total of 187 samples of bulk materials were collected at 45 properties during PDI. Refer to Appendix C for additional information on individual sample details and analytical results.

Sample results are compiled below:

| PDI Bulk Materials Sample Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | LA Detection Frequency | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Grab | PLM-9002 | 187 | 136 | - | 42 | - | 9 |

Notes: LA – Libby Amphibole; ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method

## 2.19 Pre-Design Inspections at Specialty Properties

The following sections describe the atypical PDIs performed at the same unique or complex properties as discussed in the investigation section. The locations of these properties are illustrated on Figure 2-17.

### 2.19.1 Libby School District Administration Building

Conducted concurrently with the April 2003 CSS, measurements were taken to quantify the amount of vermiculite insulation and other insulation requiring removal as part of the indoor PDI and a SIIC was completed. During this investigation, field personnel clarified that vermiculite insulation was only observed in the north addition attic. The south attic was not insulated with vermiculite insulation and did not share airspace with the north attic. Vermiculite insulation was also observed beneath the entrance to the north attic. Thirteen dust samples were collected from the horizontal surfaces and high traffic areas of the ground floor, second floor, basement, and south addition attic. Analytical results for all samples were non-detect for LA by TEM ISO. Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the indoor contamination at the Libby Administration Building is discussed in Section 2.21.6.

### 2.19.2 St. John's Rehabilitation Center and Helipad Field

In 2005, four dust samples were collected from the rehabilitation center and the two sheds within the helipad field as part of the PDI and an EIC was completed. Each structure was inspected for vermiculite insulation and no additional soil samples were necessary. The dust samples were collected in accordance with the *Final Draft Pre-Design Inspection Activities Work Plan* (CDM 2003g) with modifications. Analytical results for all four dust samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the contamination at the St. John's Helipad is discussed in Section 2.21.8.

### 2.19.3 Cabinet View Country Club

In July 2007, an outdoor PDI was conducted at the CVCC to determine the spatial extent of visible vermiculite and LA on the front nine holes of the golf course. The back nine holes of the golf course were constructed in 2007 and LA contaminated fill materials were not used during construction. All tee boxes and greens were identified for removal based on the analytical results from the previous soil sampling in 2004 and the presence a vermiculite drainage layer within 4 inches of the surface.

The golf course was divided into 100-foot by 100-foot grids, and each grid was characterized with one 30-point composite sample. Areas with visible vermiculite were excluded from the sampled area and identified for removal. A total of 268 surface soil samples were collected from the fairways, rough areas, sand traps, and driveway. In May and July 2008, an additional 26 surface soil samples were collected from the open field at the southwest corner of the CVCC property.

Analytical results for 13 soil samples detected trace LA by PLM-VE while the remaining soil samples were non-detect for LA. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 294 total soil samples.

**Cabinet View Country Club Soil Sample Results Summary**

| Sample Type | Analytical Method | Number of Analyses | Detection Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-9002 | 1 | 1 | - | - | - | - |
| | PLM-VE | 293 | 280 | 13 | - | - | - |
| | PLM-Grav | 12 | 12 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

In addition to the outdoor inspection, the pump house and 12 additional structures on the property were visually inspected for vermiculite insulation. Vermiculite insulation was observed in the pump house along the west side of the property; however, this pump house is no longer owned or operated by CVCC and is currently part of a private residence. Vermiculite insulation was not observed in any of the outbuildings remaining on the CVCC property.

The removal action which addressed the contamination at CVCC is discussed in Section 2.21.13.

Creeks??

### 2.19.4 Former Concrete Plant

In July 2007, a PDI was conducted at the two residences on the former concrete plant property (31425 and 31445 U.S. Highway 2). In addition to visually inspecting the building and soil for visible vermiculite, soil, and dust samples were collected to further delineate contamination for upcoming removal activities. EICs and VVEFs were completed for each residence and a SIIC was completed for 31445 U.S. Highway 2. All samples were collected in accordance with the *Final Draft Pre-Design Inspection Activities Work Plan* (CDM 2003g) with modifications.

The removal action which addressed the contamination at the former Concrete Plant is discussed in Section 2.21.12.

#### 2.19.4.1 Soil

A total of seven soil samples were collected from the driveways and yard surrounding the two residences where vermiculite was not observed. Each sample was a 30-point composite collected from the surface soil. Analytical results for all samples were non-detect for LA by PLM-VE. Refer to Appendix C for additional information on individual sample details and analytical results. The table below summarizes the results by analytical method and LA detection frequency for the 7 total soil samples.

| Former Concrete Plant Sample Results Summary | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Detection Frequency | | | | | |
| Sample Type | Analytical Method | Number of Analyses | Bin A ND | Bin B1 TR | Bin B <1% | Bin B2 <1% | Bin C ≥1% |
| Surface | PLM-VE | 7 | 7 | - | - | - | - |
| | PLM-Grav | 5 | 5 | - | - | - | - |

Notes: ND – nondetect; TR – trace; <1% - less than one percent; ≥1% - greater than or equal to 1 percent; PLM-9002 – polarized light microscopy NIOSH 9002 method; PLM-VE – polarized light microscopy visual area estimation method; PLM-Grav – polarized light microscopy gravimetric method; LA – Libby Amphibole

#### 2.19.4.2 Dust

A total of seven dust samples were collected from the ground floor of each residence, and from the pump house and garage on the property. Analytical results for all samples were non-detect for LA by TEM AHERA.

### 2.19.5 Kootenai Valley Head Start (formerly . . __ )

In September 2008, EPA contractors returned to the school to collect four grab samples from the sand pails where moderate levels of vermiculite were observed in June of that year. Analytical results for the four soil samples collected were non-detect for LA. It was later determined that the play sand was locally purchased earlier in 2008 from a local hardware store. Refer to Appendix C for additional information on individual sample details and analytical results.

The removal action which addressed the vermiculite observed in September is discussed in Section 2.21.2.

### 2.19.6 Libby Elementary School (formerly Asa Wood ...)

In 2009, the Libby Public School Board announced their intent to demolish Libby Elementary School in the spring of 2010 and construct a new facility in the same location. An indoor PDI was completed in December 2009 to locate and quantify the interior and exterior walls that are insulated with vermiculite. The inspection involved drilling and scoping each wall suspected of containing vermiculite. Vermiculite insulation was observed in approximately one-third of the exterior walls along the west side of the school. Vermiculite insulation was also observed in the crawlspace underneath the exterior walls with vermiculite insulation. Soil samples were collected from areas of the crawlspace where vermiculite was not observed. Analytical results of these soil samples were not available at the time of this report.

## 2.20 Removal Actions

As mentioned in Section 2.17.1, each property at OU4 may require cleanup in three general areas: the attic space, the interior living space, and outdoors. The following sections generally describe the removal action process and summarize the completed removal actions at OU4.

### 2.20.1 Clearance Criteria

As documented in EPA's Technical Memo (EPA 2003c), cleanup of a portion of a property was considered complete and the property "clean" when the following criteria were met for each of the three general areas:

*Attic Space*

- No uncontrolled vermiculite insulation remained in accessible areas.
- Any vermiculite insulation remaining was well-contained.
- The average of approximately five samples of disturbed air collected in the attic had detected levels of LA <0.01 LA by TEM.

*Interior Living Space*

- No visible vermiculite remained in accessible areas or living space.
- No LA structures were detected in any of approximately five samples of disturbed air on the level(s) or floor(s), indicating disturbed air concentrations are generally <0.001 by TEM.

*Outdoors*

- No substantial visible vermiculite or waste material remained within the area of excavation.
- In excavated areas, soil samples collected at the depth of excavation were non-detect for LA by PLM. If the maximum design depth was reached (12 inches for yards, 18 inches for SUAs), soil samples collected at the bottom of excavation were <1 percent LA by PLM.

If any of the above steps could not be met, re-cleaning, additional excavation or other steps were implemented and the collection of clearance samples was repeated. Additional excavation continued (generally to a maximum depth of three feet regardless of contamination levels) if gross contamination was observed or if analytical results indicated levels of LA ≥1 percent by PLM.

EPA's cleanup approach (EPA 2003c) considers not only the presence of source materials and the concentration of LA within them, but also the likelihood that these source materials may be disturbed. Based upon this approach, some source materials that are less likely to be disturbed may be left in place (such as in walls, below hard surfaces, and at depth). In some situations, EPA may remove or further isolate such materials to prevent even infrequent exposures, depending on the situation.

The following sections describe the types of removal activities performed at typical residential and commercial properties within OU4. Removal activities are separated into the general categories of indoor, outdoor, and structure demolition, and further separated by general removal locations (e.g., attic, living space, understructure, outdoor soils). Removal activities are described in each iteration of the *RAWP* (CDM 2000, 2003c, 2007b, 2008f), and the latest version of the *RAWP* is provided in Appendix A.

## 2.20.2 Indoor Removal Actions

Indoor removal activities generally involved the removal of vermiculite insulation, ACM, contaminated dust, or contaminated building materials from a structure, typically consisting of a residence, business, and/or associated outbuilding (e.g., garage, shop, or shed).

### 2.20.2.1 Areas of Exposed Vermiculite Insulation

Primarily, vermiculite insulation has been removed from accessible attic spaces. As established by EPA removal criteria, other insulation such as fiberglass or cellulose, if in contact or sharing airspace with vermiculite insulation, was also removed.

Following bulk insulation removal, the surfaces of the attic were detailed, and inaccessible insulation was sealed in place with encapsulant or physical barriers.

Although the majority of vermiculite insulation has been encountered in attic spaces, vermiculite insulation has also been removed from certain contained areas, (e.g., walls, floors, and ceilings) when the property owner intended to remodel their house or business immediately following the removal or where building materials were in extremely poor condition. Blocking activities were performed and encapsulant applied as necessary to seal inaccessible insulation in place.

Following removal activities, air clearance samples were collected in accordance with the *RA SAP* (CDM 2003c, Appendix A) or *RA SAP, Revision 1* (CDM 2007b), until clearance criteria were met. Each containment area had its own clearance sampling event. Approximately 3,200 indoor air clearance samples have been collected and these samples are included electronically in Appendix E, and copies of the RA SAPs are provided in Appendix A.

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Attic restoration included restoring attic accesses and installing comparable insulation. Restoration was typically not required in areas to be remodeled.

#### 2.20.2.2 Building Material Demolition

Demolition of building materials consisted of cutting, sawing, and other intrusive activities to access vermiculite insulation for removal. Typically demolition of building materials occurred in areas where vermiculite insulation was inadequately sealed in place, materials were in poor condition, or in conjunction with remodeling plans.

As described above, inaccessible vermiculite insulation was sealed in place by applying encapsulant and installing physical barriers. Air clearance samples were collected upon completion of insulation removal.

When removal activities were completed, building materials were only restored if their removal was necessary to access vermiculite insulation.

#### 2.20.2.3 Interior Cleaning

When significant quantities of vermiculite insulation were observed within a living space, or when analytical results of dust samples showed detectable levels of LA exceeding 5,000 s/cm$^2$, containment was constructed isolating the individual floor and a full interior cleaning was performed. All surfaces (horizontal and vertical) and items within the designated containment area were vacuumed (vacuums were equipped with High Efficiency Particulate Air [HEPA] filters) and/or wet-wiped. All items that were in contact with vermiculite insulation were cleaned or disposed of. In general, upholstered surfaces, carpets, and clothing were not disposed of, and remained in place.

Encapsulant was applied in suitable areas. Following removal activities, air clearance samples were collected in accordance with the *RA SAP* (CDM 2003c, Appendix A) or *RA SAP, Revision 1* (CDM 2007b), until clearance criteria were met. Each containment area had its own clearance sampling event. Approximately 4,300 indoor air clearance samples have been collected and these samples are included electronically in Appendix E.

Beginning in April 2005, a process was developed to remove isolated releases of vermiculite insulation in living spaces. These small-scale vermiculite removals (SSVR) relied on dust sample results to govern whether a full interior cleaning, a small contained cleaning, or an uncontained cleaning was required. Contained cleanings required the collection of indoor air clearance samples before containment could be dismantled. Uncontained cleanings did not require confirmation air sampling. SSVRs continued on a limited basis until July 2007 when dust sample collection was suspended. The process of identifying properties suitable for SSVR cleanings is outlined in the *Small Scale Vermiculite Removal Memorandum* (CDM 2005j) which is provided in Appendix A.

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Restoration activities consisted of returning household items to their original location.

#### 2.20.2.4 Indoor Soils

VCS and/or LA-contaminated soils were removed from the understructure of buildings (i.e., basements, crawlspaces) as needed.

When the required excavation depth was met, typically between 0 and 6 inches, and soil remaining in the excavation area was expected to meet soil clearance criteria, soil samples were collected in accordance with the *RA SAP* (CDM 2003c, Appendix A) or *RA SAP, Revision 1* (CDM 2007b), until clearance criteria were met. On occasion, indoor air clearance samples were collected in lieu of indoor soil clearance samples or the area was encapsulated. Approximately 60 indoor soil samples have been collected and these samples are included electronically in Appendix E. Properties where LA was detected in indoor soils, either at the initial or final depth, are depicted on Figure 2-24.

Excavation depths which differed from those stated in the property-specific work plans were documented.

Concrete or shotcrete was applied as a means of encapsulating remaining LA contamination within soils that were difficult to access. In rare cases, a liner covered with compacted gravel was used to encapsulate the remaining soil.

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Soil restoration activities consisted of backfilling, grading, and compaction.

### 2.20.3 Outdoor Removal Actions

Outdoor removal activities generally involved the removal of contaminated soil, rocks, or associated debris. Typical removal locations included yard, flowerbed, garden, or driveway areas.

Typical excavation depths were as follows:

| Location | Required Excavation Depth |
|---|---|
| Yard | 12 inches |
| Flowerbed | 18 inches[1] or 12 inches |
| Garden | 18 inches |
| Driveway | 12 inches |

[1] In 2007, this depth was modified to 12 inches per the direction of EPA.

During contaminated soil removal, the perimeter of the exclusion zone was monitored for asbestos structure migration by collection of stationary air samples from the downwind direction at the exclusion zone boundary. Approximately 7,000 outdoor perimeter air samples have been collected in accordance with the *RA SAP* (CDM 2003c, Appendix A) or *RA SAP, Revision 1* (CDM 2007b). Refer to Appendix E for additional information on individual sample details and analytical results.

When the required excavation depth was met and soil remaining in the excavation area was expected to meet soil clearance criteria, soil clearance samples were collected in accordance with the *RA SAP* (CDM 2003c, Appendix A) or *RA SAP, Revision 1* (CDM 2007b). Approximately 7,400 outdoor soil samples have been collected and these samples are included electronically in Appendix E. Properties where LA was detected in outdoor soils, either at the initial or final depth, are depicted on Figure 2-24.

Excavation depths which differed from those stated in the property-specific work plans were documented.

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Outdoor restoration activities consisted of backfilling, grading, compaction, installation of fences, and landscaping.

### 2.20.4 Structure Demolition

Structure demolitions involved the physical removal of structures contaminated with LA or VCBM. Heavy equipment was utilized to dismantle the buildings through controlled methods.

Perimeter air and dustfall samples were collected in configurations surrounding the demolition site. Dustfall samples are open-topped containers with a specified volume of liquid at the base that collects particulates over various time intervals that settle out of the air. Approximately 200 dustfall samples have been collected in accordance with the *General Sampling and Analysis Plan for Assessing Asbestos Release from Building Demolition at the Libby, Montana Superfund Site* (EPA 2005d) and the *General Workplan for Building Demolition at the Libby, Montana, Superfund Site, Revision* 2 (EPA 2007d) which are provided in Appendix A. The number of perimeter air samples collected is included in the total presented in Section 2.20.3. Refer to Appendix E for additional information on individual sample details and analytical results.

Following demolition, an area encompassing the structure's footprint was excavated, typically to a depth of 12 inches, and soil clearance samples were collected in accordance with the *RA SAP* (CDM 2003c, Appendix A) or *RA SAP, Revision 1* (CDM 2007b). The number of soil samples collected from the footprint of demolished structures is included in the total presented in Section 2.20.3. Refer to Appendix E for additional information on individual sample details and analytical results.

Restoration activities consisted of backfilling, grading, and compaction but did not require restoration of the demolished structure.

### 2.20.5 Completed Properties

A property is classified as "completed" when a removal action has taken place and all contamination, as defined in the December 2003 removal action and clearance criteria technical memorandum, is addressed. Upon completion, a summary of removal activities for each property are documented on a *Property Closeout Checklist* (PCC).

Between 2001 and December 31, 2009, a total of 1,202 property groups have been completed. The following table shows the total amount of removals, by removal type.

| Type of Removal Activity | Number of Property Groups |
|---|---|
| Indoor | 212 |
| Outdoor | 489 |
| Combination (e.g., Indoor and Outdoor or Outdoor and Demolition) | 501 |

The total number of completed properties presented in this section may differ from total removal counts previously reported to or by EPA due to the following:

- Excludes completed properties in other OUs
- Adjusted for individual addresses reported as individual cleanups rather than as one completed property group (as discussed in Section 2.17.2)
- Adjusted for multiple removals over multiple years at the same property reported as individual cleanups

- Adjusted for large property removals that were reported as more than one cleanup due to the increased level of cleanup effort

Additional contamination identified after the initial removal action (e.g., vermiculite insulation exposed due to homeowner remodeling, results of post cleanup or risk-assessment based sampling programs) will not alter a property's completion status. The additional contamination may be addressed currently, as a "quick response" under the Environmental Resource Specialist (ERS) program, or later, as part of a modified response action program *if* EPA's removal criteria are changed.

What happen if criteria changes due to new Tox values and trigger level lowers?

***Partially Completed Removal Actions***
Quick responses are a necessary component of the removal action program that provides EPA with a means to quickly address unexpected releases of vermiculite and mitigate potential exposures to LA. Quick responses can occur at properties at any stage in the investigation, design, or removal phase including completed properties and properties where an initial contamination screening has not occurred.

Quick responses are most commonly encountered during building repair, remodeling, maintenance, utility servicing, installation, and construction. The process governing the ERS program is documented in the *Environmental Resource Specialist Plan* (CDM 2009f) which is provided in Appendix A.

Although quick responses and other partial removal actions have been conducted at many properties since 2001, 45 properties have partially had contamination addressed without undergoing a complete removal action. The level of severity for a quick response varies significantly, however; small releases of vermiculite insulation that are removed with a HEPA vacuum and that do not require mobilization of an abatement contractor are not classified as partial removal actions. The summary of removal activities for partial removal actions is also documented for each property on a PCC form.

Completed and partially completed property groups are shown on Figure 2-25. The remediation status of each property group where a removal action has not taken place is shown on Figure 2-26.

## 2.21 Removal Actions at Specialty Properties

The following sections describe removal actions performed through 2009 at unique or complex properties within OU4. The locations of these properties are shown on Figure 2-17.

### 2.21.1 Libby High School

The track and a portion of the tennis courts were excavated in June 2001 and rebuilt in 2002. VCS and/or LA contaminated soil was excavated to an average depth of 2 feet. Perimeter air monitoring samples were collected over the duration of the removal. Once the native soils were reached, confirmation samples were collected to ensure the contamination was removed. If LA was detected in any confirmation sample, an additional 4 to 6 inches was excavated and the area was retested until LA was not detected at depth. The track was then reconstructed with structural fill, a geotextile fabric, crushed stone, and a 1-inch layer of finish course paving.

The elevated dust sample results from the football field storage building, snack bar, press box, visitors' coach box, storage garage, and bleachers triggered interior cleanings. Air clearance samples were collected following the cleanings. EPA purchased new football, track, and vending machine equipment for the school.

In December 2008, indoor removal activities addressed contamination identified in two greenhouses attached to the school.

The removal activities included: dismantling and removing drawers from a shelving unit; cleaning miscellaneous items; temporarily removing wooden flooring; removing soil within planters and flowerpots; and excavating the soil to a depth of 3 inches. Soil confirmation samples were then collected and an interior cleaning of both greenhouses performed. Air clearance samples were collected following the interior cleanings. Restoration included backfilling the excavation, replacing the removed flooring, and replacing the demolished shelving in-kind.

### 2.21.2 Kootenai Valley Head Start (formerly Plummer... )

Outdoor removal activities at the former ice rink began in July 2001. Initially, four test pits were excavated to determine the lateral extent of the contamination surrounding the former ice rink. Vermiculite was only observed in the first test pit; therefore, an additional test pit was excavated 5 feet away from the location of the observed vermiculite. VCS was then excavated from the former ice rink. On average, the total depth of exaction was 12 inches. Once the design depth was reached, confirmation samples were collected to ensure the contamination was removed. If LA was detected in any confirmation sample, an additional 12 inches was excavated and the area was retested until LA was not detected at depth.

Perimeter air samples were collected during the 2001 removal event.

Due to vermiculite observed in the former pond area, an additional outdoor removal began in October 2002. During excavation, a vein of mine tailings was observed approximately 15 feet from the former ice rink. Test pits were excavated to determine the lateral extent of this vein, and the excavation extended to include these new areas. Adjacent to the asphalt along Education Way, the depth of the excavation reached 24 inches when a 1-2 inch layer of vermiculite was observed. This vein of vermiculite was removed to the extent possible, but it was noted that the material extended underneath this asphalt for an unknown distance. Confirmation soil samples were collected at depth to ensure all accessible contamination had been removed.

Perimeter air samples were collected during the 2002 removal event.

In September 2008, EPA contractors returned to the school and discovered one of the sand pails being used in a classroom. All pails of sand were removed from the school, the area surrounding the play table was HEPA vacuumed, and the carpet underneath the table was removed. Vermiculite insulation was also observed during this supplemental visit along the wall in the parent's waiting room. Presumably, the insulation came from the exterior cinderblock wall. An interior cleaning was performed in the supply closet in the parent's waiting room and the storage room at the south end of the gymnasium.

### 2.21.3 Libby Middle School

Outdoor removal activities of the Libby Middle School track began in August 2001. Although the excavation was completed by the end of September 2001, the track was not rebuilt until 2002. VCS and/or LA contaminated soil was excavated to an average depth of 2 feet, or 6 inches below the visual change in strata below the contaminated layer. Perimeter air monitoring samples were collected over the duration of the removal. Once the final depth had been reached, confirmation samples were collected to ensure the contamination was removed. If LA was detected in any confirmation sample, an additional 4 to 6 inches was excavated and the area was retested until LA was not detected at depth. The track was then reconstructed with structural fill, a geotextile fabric, crushed stone, and a 1-inch layer of finish course paving.

In June 2004, gross quantities of vermiculite were observed on the steep bank in the southeast corner of the school grounds near the fence line of 906 West Balsam Street. An urgent unscheduled cleanup of this area was performed and completed on August 26, 2004. VCS was removed to a depth of 12 inches and confirmation samples were collected to ensure the contamination was removed. The area was restored to grade with backfill materials and hydroseeded.

In April 2009, EPA removed the high jump mat from the Middle School's athletic field and replaced it in-kind.

### 2.21.4 Kootenai Bluffs Subdivision

Based on visual inspections and the results of pre-removal surface and subsurface soil sampling at the Kootenai Bluffs Subdivision, EPA determined that an outdoor removal action was required.

EPA conducted this work between August 9 and November 18, 2001 in accordance with the *Final Removal Action Work Plan for the Kootenai Bluff Property* (CDM 2001) which is provided in Appendix A. In general, VCS was excavated to a depth of 18 inches throughout the removal areas. In accordance with the work plan, additional 6-inch lifts were removed if analytical results detected LA at concentrations $\geq$1 percent.

Following excavation and confirmation soil sampling, the area was restored with appropriate backfill materials.

### 2.21.5 Cemetery Park Ball Fields

Indoor removal activities of the concession stand began in May 2002 and were completed in June 2002. Work performed consisted of an interior cleaning of the concession stand, including equipment inside the stand. The stand and sports equipment were HEPA vacuumed and/or wet wiped. Air clearance samples were collected from the concession stand after the interior cleaning. Restoration included returning items to their original location.

## 2.21.6 Libby School District Administration Building

Indoor removal activities of the Administration Building attic began in July 2003 and were completed by the end of August 2003. Work performed consisted of vermiculite and fiberglass insulation removal from the north addition attic and an interior cleaning of the storage room, closet and entryway of the northeast classroom. Once the insulation was removed, the attic was detailed and encapsulated.

Air clearance samples were collected from the storage room after the interior cleaning and from the attic after the insulation removal. Restoration included installing insulation and returning items to their original location.

## 2.21.7 Johnston Acres Subdivision

Although the initial subsurface investigation of the Johnston Acres Subdivision (Section 2.5.14) did not confirm the presence of contaminated fill material, several areas of contamination were encountered during the waterline replacement in 2005.

- 1408 Washington Avenue – a 2 to 6 inch vein of vermiculite and tremolite was encountered between the topsoil and native soil layers.
- 1417 Washington Avenue – vermiculite was encountered south of the house surrounding the existing water pipes.
- 131 West Larch Street – a vein of visible vermiculite was encountered approximately 12 inches bgs in a trench perpendicular to Larch Street.
- 1511 Main Avenue – vermiculite was observed on the surface of the soil from the water line along Main Avenue to the yard of 1511.

In each situation, EPA removed the contaminated soil to ensure the waterline installation could safely continue without spreading contamination. Soil clearance samples were not collected during these partial removal actions. Restoration was performed by the waterline contractor once their installation was completed.

## 2.21.8 St. John's Rehabilitation Center and Helipad Field

Outdoor removal activities of the helipad field began in August 2005 and ended in October 2005. VCS and/or soil with detectable levels of LA were excavated to depths of 12 inches to 36 inches. Pocket-like sections with gross quantities of vermiculite were observed in many locations on the property during excavation. In addition, contaminated soil was removed from the planter boxes at the rear of the Rehabilitation Center. Perimeter air samples were collected throughout the duration of the removal, and soil clearance samples were collected following completion of excavation.

The north half of the property was restored with common fill, topsoil, and hydroseed to replicate the landscape's original state. No restoration was required in the south half of the property due to pending construction plans for a new facility; EPA accordingly left a stockpile to topsoil to be used at the discretion of the hospital. In addition, gravel was placed to restore a haul road along the west edge of the property. A detailed summary of this removal action is presented in the *2005 CDM Oversight Activities Conducted at the St. John's Hospital Helipad Property in Libby, Montana Memorandum* (CDM 2005k) which is provided in Appendix A.

### 2.21.9 J. Neils Park

In September 2005, outdoor removal activities began at the infield portions of fields 1 and 2 (i.e., the softball fields). Removal work performed included excavation of VCS to depths of 12 to 18 inches. Perimeter air samples were collected during removal work. Soil clearance samples were collected following excavation. Restoration of the areas included placement and compaction of common fill and ¾-inch-minus rock.

Additional outdoor removal activities began in June 2008 when vermiculite was observed at the soccer field in the northeast portion of the park. Removal work performed included removal of soil stockpiles along the west edge of the area, and excavation of VCS at the soccer field location to depths of 6 to 12 inches. Perimeter air samples were collected during the removal work. Soil clearance samples were collected following removal and excavation. Restoration of the removal areas was not required.

### 2.21.10 City of Libby Alleys

Removal actions have taken place at five alleys within the city limits. Each alley was excavated to a depth of 12 inches to remove VCS and/or soil with detectable levels of LA. Refer to Figure 2-18 for the locations of the alleys discussed below.

- Outdoor removal activities at Alley #124 were conducted in June 2007.
- Outdoor removal activities at Alley #111 were conducted in September 2007.
- Outdoor removal activities at Alley #109 were conducted in October 2007.
- Outdoor removal activities at Alley #31 were conducted in May 2008.
- Outdoor removal activities at Alley #61 were conducted August 2009.

In each alley removal, perimeter air samples were collected during removal work, and soil clearance samples were collected following completion of excavation. Alley restoration included placement and compaction of residential fill and structural fill.

### 2.21.11 Libby Elementary School (formerly Asa Wood ... )

In January 2008, vermiculite insulation spilled out onto the ground from an exterior wall that was punctured by a piece of snow removal equipment. The insulation was removed from the surface of the snow and surrounding soil. Soil clearance samples were not collected to confirm the removal.

### 2.21.12 Former Concrete Plant

In June 2009, indoor and outdoor removal activities began at the residential portions of the former Concrete Plant, 31425 U.S. Highway 2 and 31445 U.S. Highway 2. Work performed at 31425 U.S. Highway 2 consisted of vermiculite and fiberglass insulation removal, an interior cleaning of the ground floor, and excavation of VCS and/or soil with detectable levels of LA from the yard and flowerbeds. Work performed at 31445 U.S. Highway 2 consisted of excavation of contaminated soil from the yard and flowerbeds only. Soils were removed to a depth of 12 inches in the yard and flowerbeds. A concrete pad, concrete cistern, and barbed wire fence were removed without replacement.

Air clearance samples were collected from the ground floor of 31425 U.S. Highway 2 after the interior cleaning and from the attic after the insulation removal. Perimeter air samples were collected during the outdoor removal work, and soil clearance samples were collected following completion of excavation. Property restoration included placement and compaction of topsoil, residential fill, and structural fill.

### 2.21.13 Cabinet View Country Club

Outdoor removal activities began in August 2009 and ended in October 2009. Removal activities included: excavation of VCS from areas throughout golf holes #s 1-9 and around facility buildings; demolition of a shed; and stump removal. VCS was excavated to depths of 12 inches to 48 inches. Perimeter air samples were collected during the removal. Soil clearance samples were collected following completion of excavation.

Golf course restoration included placement and compaction of residential fill and topsoil.

* Creeks ?

## 2.22 Quality Assurance/Quality Control

The quality of work conducted by EPA in Libby is ensured through the implementation of a rigorous quality assurance (QA) program for field activities, soil sample preparation activities, and analytical laboratory activities. The QA program specifies use of certain QA/QC procedures and measures, which are specified in governing documents and detailed in this section. The QA program also employs an auditing component to assess the effectiveness of the program. An evaluation of the data quality indicators; precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters for data collected at the Libby Site was drafted in 2007 (SRC 2007b) and is currently in review at EPA. As such, the PARCC parameters were not completely reevaluated for this report; however, general conclusions regarding data usability and data quality objectives (DQOs) are drawn.

## 2.22.1 Field Quality Assurance/ Quality Control

The general processes and procedures used during field activities at OU4 are discussed in this section, along with related QA/QC protocols. It is the responsibility of the project manager and task-specific field team leader (FTL) to ensure all QA/QC procedures, as specified in governing documents, are followed.

### 2.22.1.1 Field Documentat ion

QA/QC measures related to field documentation are discussed below.

*Field Forms*
Field forms used to capture property-specific information are typically included as appendices in the task-specific field plan. If field forms are required to be completed as part of field activities, the field plan also provides guidance on completing the form, as well as form maintenance and distribution. Each field form is checked for accuracy and completeness by a second team member before it is considered complete. The FTL also completes periodic checks, typically at a rate of 2 percent, for form accuracy and consistency among field teams. If errors are observed during either check, the author corrects the recorded information. Major deficiencies in completing field forms require retraining on form completion procedures.

*Field Sample Data Sheets*
Field Sample Data Sheets (FSDSs) are completed in accordance with the current version of CDM-LIBBY-03. As the sheets are completed, field team staff other than the author checks to ensure the data is complete and accurate. If errors are observed during the check, the author corrects the recorded information. Major deficiencies require retraining on FSDS completion procedures.

*Logbooks*
A team member other than the author (e.g., FTL, QA staff) periodically checks logbook entries for completeness and accuracy. If any logbook entries are incorrect or incomplete, the author corrects the entry. Major deficiencies require retraining on logbook documentation procedures.

*Property-Specific Information and Sample Database*
The electronic Libby Asbestos Sample Tracking Information Center (eLASTIC) database is used to capture property-specific and sample information, as described in the current version of the eLASTIC SOP (CDM-LIBBY-11). Field team staff other than the person who performed the data entry checks 100 percent of the data entered into eLASTIC. If data entry discrepancies are discovered during the QC check, a correction is made to the entered data. Following the data entry check, data is submitted for upload into the project database. Major deficiencies in data entry require retraining on eLASTIC data entry procedures.

#### 2.22.1.2 Field Equipment

Quality processes related to field equipment are discussed below.

*Calibration and Maintenance Procedures*
Field calibration and maintenance procedures are included in the documents governing field work. Generally, field equipment is calibrated and maintained in accordance with manufactures specifications. Each calibration step is documented in a logbook and/or equipment-specific calibration log. Designated field team staff verifies that the calibration of each piece of equipment is checked daily and is operating within normal parameters.

*Equipment Decontamination*
When sampling equipment is used in an environment where asbestos structures may be present (e.g., attics), the equipment is wiped down using commercially available wet-wipes or paper towels moistened with locally available distilled water in accordance with requirements stated in the task-specific field plan. Materials used in the decontamination process are disposed of as IDW in accordance with specified procedures for handling IDW.

#### 2.22.1.3 Field Q uality Control Samples

Sampling accuracy may be assessed through the use of field QC samples that help identify errors associated with sample collection, handling, and analytical procedures. This section discusses field QC samples associated with OU4 sampling. Field QC sample collection procedures, as well as field QC sample collection and analysis frequencies, are outlined in each task-specific field plan.

The types of field QC samples collected at OU4 include: lot blanks, field blanks, field duplicates, field replicates, field splits, equipment blanks, and rinsate blanks. These QC samples were collected and analyzed in accordance with the governing documents for each sampling event. Asbestos analytical results for all field QC samples are provided in Appendix F.

*Lot Blanks*
Lot blanks are collected to ensure that sampling supplies (e.g., air and dust sample cassettes, silica sand) are asbestos-free before they are used to collect samples.

For air and dust sample cassettes, cassette lot blanks from each manufacturer's lot are randomly selected and analyzed using the same method used for field sample analysis (i.e., PCM and/or TEM). Lot blank results are reviewed before any cassette in the lot is used for sample collection. The entire batch of cassettes is rejected if fiber or asbestos structure counts exceed the analytical method detection limit. Only lots of filters with acceptable lot blank results are placed in the general supply area for use by project personnel.

As presented in Appendix F, data is available for 719 air and dust cassette lot blanks. All lot blank data indicate fiber or asbestos structure counts below the detection limit of the analytical method. As a result, air and dust cassettes from the same lot as the lot blanks were deemed acceptable for use in sample collection.

Prior to use of silica sand for soil equipment blanks, two silica sand lot blanks were collected and analyzed using the same method used for field sample analysis (PLM). Both lot blank sample results were non-detect for LA, indicating the sand was suitable for use in collecting equipment blanks.

*Field Blanks*

Field blanks are used to evaluate sample collection and handling techniques and potential ambient interferences. Field blanks are analyzed for asbestos by the same method that is used for field sample analysis. If asbestos is observed on a field blank, other field blanks collected the same team may be submitted for analysis to determine the potential impact on related field sample results.

A total of 5,024 air and dust field blanks were collected and analyzed. With the exception of six (0.1 percent) field blanks, field blank data indicate fiber or asbestos structure counts below the analytical method detection limit. Collectively, this data suggests very low error associated with sample collection and handling. Some of the field blank detections may have been attributed to ambient interferences.

Seven water field blanks were collected, results of which were all non-detect for LA. This field blank data suggests low error associated with water sample collection and handling.

*Field Duplicates, Field Replicates, and Field Splits*

In Libby, field duplicates, field replicates, and field splits are primarily collected to assess error associated with sample heterogeneity or sample reproducibility. For air and dust media, field duplicates and field replicates are interchangeable terms and are defined as separate samples collected at the same location and time as the related field samples but using separate pumps and cassettes. For soil, field duplicates and field splits are interchangeable terms and are defined as separate samples collected from the same land use area as the related field sample but from different subsample locations. The soil field duplicate/split is collected from the same number of subsamples as the parent sample.

As part of air and dust sampling activities at OU4, 23 field duplicates and 24 field replicate samples were collected and analyzed. Due to the limited number of these field QC samples, no conclusions are drawn from their results regarding sample heterogeneity or sample reproducibility. Results for air and dust field duplicates and field replicates, along with their paired field sample results, are provided in Appendix F.

Alternatively, previous evaluations of Libby soil field duplicate and soil field split sample data indicate a certain level of heterogeneity (i.e., low sample reproducibility) within sampled areas. Therefore, results of soil field duplicates and soil field splits have been considered, along with results of soil field samples, in identifying contaminated soil for removal actions. Soil field duplicate and soil field split sample data is discussed along with soil field sample data throughout this report.

In total, eight OU4 water field duplicates were collected. With one exception, all field duplicate results and the corresponding field sample results were non-detect for LA. However, based on this limited data set, no conclusions are drawn regarding sample heterogeneity or reproducibility.

*Equipment Blanks and Rinsate blanks*

Equipment blanks and rinsate blanks are used to determine if field equipment decontamination procedures are adequate to prevent sample cross-contamination.

Equipment blanks are collected by pouring asbestos-free silica sand over decontaminated field sampling equipment. A total of 292 silica sand equipment blanks were collected at OU4. With one exception (0.3 percent of the total), analytical results for the equipment blanks were all non-detect for LA, suggesting effective equipment decontamination procedures.

Rinsate blanks are collected by pouring de-ionized water over decontaminated field sampling equipment. A total of 22 rinsate blanks were collected and analyzed, 19 of which were collected during the 2002 CSS effort. Following EPA evaluation of these 19 results, it was determined that it was not necessary to continue to collect rinsate blanks during the 2003 CSS/RI effort. Rather, equipment blanks continued to serve as a QC measure during the 2003 CSS/RI and subsequent field efforts. Results of the three additional rinsate blanks associated with the USGS background study conducted in 2008 (Section 2.14) were non-detect for LA, indicating effective equipment decontamination procedures.

#### 2.22.1.4 Field Sample Custody and Handling

Field sample custody procedures are conducted in accordance with the requirements stated in the task-specific field plan. A chain-of-custody form (COC) is used as physical evidence of sample custody and control and is required to accompany each shipment of samples.

At OU4, all samples and corresponding FSDSs are relinquished to the field sample coordinator by the sampling team following strict custody procedures. The field sample coordinator then enters sample information into eLASTIC and, following the required quality data entry check, prepares a COC. For samples analyzed at the onsite Libby asbestos laboratory, the field sample coordinator verifies the sample labels with the COC then delivers/relinquishes samples following appropriate custody procedures. For samples being shipped offsite, the field sample coordinator verifies the shipment contents with the COC before custody seals are placed on the shipping container. The field sample coordinator maintains responsibility for tracking sample shipments and coordinating with receiving parties to ensure timely sample receipt and analysis.

#### 2.22.1.5 Field Team Training

Prior to starting work at OU4, new field team staff must complete the following, at a minimum:

- Read the *Comprehensive Site Health and Safety Program* (CDM 2006a) - documented on plan signature sheet and investigation-specific Required Reading Report
- Attend an orientation session with the Site health and safety officer - documented on orientation session attendance sheet.
- Read and understand all relevant governing documents - documented on a task-specific required reading report.

Depending on the work to be conducted, additional training may apply. These requirements may include the following:

- OSHA 40-hour Hazardous Waste Operations and Emergency Response and relevant 8-hour refreshers - documented by training certificates.
- Respiratory protection as required by 29 CFR 1910.134 - documented by training certificate.
- Asbestos awareness as required by 29 CFR 1910.1001 - documented by training certificate.
- Sample collection techniques - documented by field logbook entries or on training session attendance sheets.
- Identification of vermiculite and Libby mine-related materials - documented by field logbook entries or on training session attendance sheets.

Copies of certifications and documentation of trainings are maintained in the Libby project files.

#### 2.22.1.6 Field Quali ty Assurance Manager Reports

For certain field events such as the CSS and Supplemental RI, Quality Assurance Manager (QAM) reports were required to be prepared by a field QAM. These reports were typically prepared on a weekly or monthly basis during field activities and served as an independent check to ensure field QC measures were being followed by the FTL and field team staff. If any deficiencies were noted during a QAM reporting period, the FTL was immediately notified and necessary improvements or corrective action was taken.

#### 2.22.1.7 Field Surveillance s and Audits

*Field Surveillances*

Field surveillances consist of periodic observations that evaluate adherence to task-specific governing documents. The schedule for performing field surveillances depends upon the duration of the field event, frequency of execution, and magnitude of process changes. At a minimum, surveillance is performed daily (typically by the FTL) during the first week of a new field program. Thereafter, surveillance is conducted once a month or as necessary when field processes are revised or other QA/QC procedures indicate the possibility of deficiencies. When deficiencies are observed during surveillance, it is the responsibility of the FTL to make necessary improvements or take corrective action.

***Field Audits***

Field audits are broader in scope than surveillances. Audits are evaluations conducted by qualified technical or QA staff that are independent of the activities audited. Field audits can be conducted by CDM, internal EPA staff, or EPA-contracted auditors.

One field audit is typically conducted during the early stages of a field program to identify deficiencies so that the impact on data quality is mitigated or minimized. At least one field audit is conducted on all field programs having duration of one year.

Field audit findings are documented in audit reports issued by the entity that performed the audit, and are often discussed with field team management before the auditors leave the Site. Process improvements or corrective action is immediately implemented as appropriate.

## 2.22.2 Close Support Facility Quality Assurance/Quality Control

Investigation soil samples are prepared for analysis at the CDM Close Support Facility (CSF) via a process that includes drying, sieving, splitting, grinding, and archiving. The activities at the CSF are performed in accordance with the *CSF Soil Preparation Plan, Revision 1* (CDM 2004e) and the current version of ISSI-LIBBY-01 which are provided in Appendix A. QA/QC of the soil preparation process is maintained using designated QA/QA procedures, each of which is discussed in this section.

### 2.22.2.1 CSF Documentation

QA/QC steps related to CSF documentation are discussed below.

***Preparation Sample Data Sheets***

Preparation sample data sheets and preparation log sheets are completed in accordance with the current version of ISSI-LIBBY-01. As the sheets are completed, CSF personnel other than the author check to ensure the data are complete and accurate. If errors are observed during the check, the author corrects the recorded information.

***Sample Preparation Log***

On days when samples are prepared, the CSF sample coordinator checks the batch sample preparation log to ensure all entries are complete and correct. If any entries are incomplete or incorrect, the author corrects the form.

*Logbooks*
A person other than the author checks logbook entries on a weekly basis for completeness and accuracy. If any logbook entries are incorrect or incomplete, the author corrects the logbooks entry.

*CSF Sample Database*
A CSF version of the eLASTIC database is used to track information specific to the sample preparation process as described in the CSF eLASTIC SOP. Close Support Facility personnel other than the person who completed the data entry check 100 percent of the data entered into the CSF eLASTIC database. Following the data entry check, data is submitted for upload into the project database. If data entry discrepancies are discovered during the QC check, a correction is made to the entered data.

Major deficiencies in completion of any CSF documentation require retraining on those procedures.

### 2.22.2.2 CSF Equipment

Quality processes related to CSF equipment are discussed below.

*Calibration and Maintenance Procedures*
A summary of calibration and maintenance procedures used at the CSF is presented in the *CSF Soil Preparation Plan* (CDM 2004e). Each calibration step is documented in a logbook and equipment-specific calibration log. The CSF sample coordinator verifies that the calibration of each piece of equipment is checked daily and is operating within normal parameters.

*Equipment Decontamination*
CSF equipment decontamination procedures are included in the *CSF Soil Preparation Plan* (CDM 2004e). Materials used in the decontamination process are disposed of as IDW.

### 2.22.2.3 CSF Quality Control Samples

Three types of QC samples are collected during the soil sample preparation process: preparation duplicates, drying blanks, and grinding blanks. The *CSF Soil Preparation Plan* (CDM 2004e) summarizes the collection procedures and frequency for each QC sample type collected at the CSF. This section describes each QC sample type and includes a brief description of acceptance criteria as appropriate.

*Preparation Duplicates*
Preparation duplicates aid in evaluating the precision of sample preparation and analytical procedures. A preparation duplicate is prepared by dividing the preparation sample into two approximately equal portions, thus creating a parent and duplicate sample. Both samples are then analyzed by the same method. Inconsistent sample results may indicate variability in sample preparation, and steps may need to be taken to identify and address the source of the variability in the sample preparation process.

*Drying Blanks*
Drying blanks help to determine if cross-contamination occurs during sample drying. One drying blank is processed with each drying batch per oven. If any asbestos structures are observed on a drying blank, results for field samples associated to the drying blank may be qualified. If asbestos structures are observed, the oven is immediately cleaned. If asbestos structures are observed on drying blanks submitted after oven cleaning, the drying method and oven decontamination procedures are evaluated.

*Grinding Blanks*
Grinding blank samples are prepared to determine if decontamination procedures of laboratory equipment used to prepare soil samples are adequate to prevent cross-contamination of samples during sample grinding and fine ground sample splitting. If any asbestos structures are observed on a grinding blank, results for field samples associated to the drying blank may be qualified. If asbestos structures are observed, the grinder is immediately cleaned. If asbestos structures are observed on grinding blanks submitted after grinder cleaning, the grinding method and decontamination procedures are evaluated.

### 2.22.2.4 CSF Sample Custody and Handling

Upon arrival at the CSF, samples are cross-referenced to the COCs forms contained in the shipment. If any discrepancies are found, the CSF sample coordinator notifies the field sample coordinator for rectification.

After soil samples are processed and ready to be shipped to the analytical laboratory, a new COC is prepared, which accompanies each sample shipment originating from the CSF. Prior to shipping, the CSF sample coordinator checks the visual appearance of each sample against the sample suffix to ensure that each sample is labeled correctly, and verifies that all samples are accounted for and all sample and COC information is correct.

### 2.22.2.5 CSF Staff Training

Personnel performing soil sample preparation activities must read and understand all documents governing CSF operations. Prior to performing activities at the CSF, new staff are instructed by an experienced member of the CSF staff and training sessions are documented via logbook.

### 2.22.2.6 CSF Periodic Monitor ing

An environmental monitoring program was developed to assess potential exposure and to document facility cleanliness at the CSF. As detailed in the *CSF Soil Preparation Plan* (CDM 2004e), facilities monitoring consists of collecting ambient air samples, personal air samples, and microvacuum dust samples on a bi-monthly basis when samples are processed 10 or more days for two consecutive months. The *CSF Soil Preparation Plan* summarizes the acceptance criteria and corrective actions based on results of facilities monitoring samples.

#### 2.22.2.7 CSF Quality Assurance Manager Reports

QAM reports are prepared by the QAM assigned to the CSF on a monthly basis when sample preparation activities are occurring. Details of QAM report generation are provided in the *CSF Soil Preparation Plan* (CDM 2004e). Similar to field QAM reports, CSF QAM reports serve as an independent check to ensure CSF QC measures are implemented correctly. If any deficiencies are noted during a QAM reporting period, the CSF manager is immediately notified and necessary improvements or corrective action is taken.

#### 2.22.2.8 CSF Audits

If significant procedural changes occur to the *CSF Soil Preparation Plan* (CDM 2004e) or other governing documents, internal CDM audits are conducted to ensure the new methods are implemented correctly. Audit reports, as well as any corrective action reports, are completed following each CDM audit. EPA and Volpe Center representatives may also conduct independent audits of CSF operations at any time.

### 2.22.3 Laboratory Quality Assurance/Quality Control

Samples collected at OU4 are analyzed in accordance with standard EPA and/or nationally recognized analytical procedures. The purpose of using standard procedures is to provide analytical data of known quality and consistency. Laboratories that analyze Libby field samples must maintain particular certifications and must satisfactorily complete project-specific training requirements to ensure that proper QA/QC practices are conducted during sample analysis. Laboratory QA/QC is discussed further in this section.

#### 2.22.3.1 Laboratory Certification

All contracted asbestos analytical laboratories must be accredited by the National Institute of Standards and Technology (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) for the analysis of bulk asbestos PLM and the analysis of airborne asbestos by TEM. This includes the analysis of NVLAP standard reference materials or other verified quantitative standards, and successful participation in two proficiency rounds per year each of bulk asbestos by PLM and airborne asbestos by TEM supplied by the NVLAP.

Project laboratories are also required to successfully participate in the Proficiency Analytical Testing (PAT) program of the American Industrial Hygiene Association (AIHA) for PCM. The PCM proficiency testing samples are submitted directly to the laboratories from AIHA on a quarterly basis.

Copies of recent proficiency examinations from both NVLAP and the AIHA or an equivalent program are maintained for each participating laboratory in the CDM project files.

Each laboratory also maintains appropriate certifications from state and possibly other certifying entities (e.g., State Department of Transportation) for methods and parameters that may also be of interest to the Libby project. These certifications require that each laboratory has all applicable state licenses and employs only qualified personnel. Laboratory personnel working on the Libby project are reviewed for requisite experience (at least three years) and technical competence to perform asbestos PCM, PLM, and TEM analyses, and SEM, if available.

#### 2.22.3.2 Laboratory Documentation

QA/QC measures related to laboratory documentation are presented below.

*Data Reports*
Data reports are submitted to the CDM laboratory coordinator and include a case narrative that briefly describes the number of samples, the analyses, and any analytical difficulties or QA/QC issues associated with the submitted samples. The data report also includes signed COCs, analytical data summary report pages, a QC package, and raw data, where applicable. Raw data is to consist of instrument preparation logs, instrument printouts, and QC sample results including instrument maintenance records, COC check-in and tracking, raw data instrument print-outs of sample results, analysis run logs, and sample preparation logs. Once issued, all data reports are reviewed by the CDM laboratory coordinator (or designate) and any errors rectified with the laboratory. All original data reports are maintained in the CDM project file. The laboratory also provides an electronic copy of the data to the laboratory coordinator and others as directed by CDM.

*Laboratory Electronic Data Deliverables*
Standardized data entry spreadsheets were developed specifically for the Libby project to ensure consistency between laboratories in the presentation and submittal of analytical data. In general, a unique Microsoft Excel workbook template was developed for each type of analytical method (e.g., TEM, PCM, PLM). Since the beginning of the Libby project, the electronic data deliverables (EDDs) have evolved to better accommodate the present and future needs of data handling, retrieval, and interpretation. Ongoing refinement of the EDDs may continue based on EPA, data user, and laboratory input.

The EDD template contains a variety of built-in QC functions that improve accuracy of data entry and help maintain data integrity. For example, data entry forms utilize drop-down menus whenever possible to standardize data inputs and prevent transcription errors. In addition, many data input cells are coded to highlight omissions, apparent inconsistencies, or unexpected values so that data entry personnel can check and correct any errors before submittal of the EDD. The spreadsheet workbook also performs automatic computations of sensitivity, dilution factors, and concentration, thus reducing the likelihood of analyst calculation errors. The EDD was designed to directly upload data into The project database, avoiding any additional data entry requirements.

#### 2.22.3.3 Analytical Method QA/QC

QA/QC measures related to specific analytical methods are detailed herein.

*PCM*

Laboratory QA/QC for samples analyzed via PCM is maintained by following the requirements specified in the method, which is based on satisfactory performance of AIHA requirements. This laboratory accreditation is designed specifically for laboratories involved in analyzing samples that are used to evaluate workplace exposure. The AIHA requirements include: personnel qualifications, participation in the PAT program for all categories of analytes performed by the laboratory, adequate testing facilities, QC procedures including records of onsite airborne asbestos analyses, a laboratory records and recordkeeping system, a method review program, and onsite audits performed every two years.

*TEM (including ASTM)*

Laboratory QA/QC for TEM samples is maintained by following the requirements specified in the method, which is based on satisfactory performance of NVLAP requirements. This laboratory accreditation signifies the competency of a laboratory to provide testing services. The third-party accreditation complies with the standards published by ISO and the International Electrotechnical Commission (IEC), specifically ISO/IEC 17025.

The NVLAP program reviews management and technical requirements pertaining to quality systems, personnel, facilities, test and calibration methods, equipment, measurement traceability, sampling, handling of test and calibration items, and reporting. In addition, laboratories are required to participate in one proficiency testing activity per accreditation on a minimum frequency interval of every four years. Unsatisfactory performance due to non-participation in regularly-scheduled proficiency test rounds or unresolved technical nonconformities can subject a laboratory to denial or suspension of their accreditation and subsequent suspension on the Libby project.

Additional project-specific QA/QC requirements for TEM methods are documented via Laboratory Modification Forms LB-000029, LB-000029a, and LB-000029b. These provide guidelines to standardize the frequency of QC sample preparation and analysis for all TEM methods, and are detailed in the *Draft Analytical Methods Summary for OU4* (CDM 2009a).

*PLM*

For all PLM methods, the following project-specific requirements are employed to ensure QA/QC of PLM analysis:

- Refractive index liquids are checked daily for asbestos contamination.
- Refractive indices of the refractive index liquids are verified once per week.
- Microscope adjustments are verified prior to each sample set.
- Reference samples or laboratory control samples are checked against USGS standards daily.

- Replicate slides are prepared.
- Standardized bench sheets are employed.
- Standardized case narrative information is used.
- Laboratory duplicate samples are submitted, as required.

Laboratory QA/QC for samples analyzed by PLM-9002 or PLM-VE is maintained by laboratory- and method-required QA/QC procedures. Laboratory-based QA/QC for these two methods is based on the requirements specified by NVLAP, which includes daily evaluation of various blanks to check for contamination. Overall QC sample analysis is at a rate of at least 10 percent, including inter- and intra-analyst reanalyses, interlaboratory sample analysis, and blank analysis. Additional project-specific QA/QC requirements for these analytical methods have not been established.

The PLM-VE method defines method precision and accuracy as the frequency with which samples are assigned to the correct "bins." Bin assignment accuracy is being collected; however, performance criteria have not yet been established for bin assignment by the analyst. The PLM-VE method also contains proficiency requirements associated with an annual blind set of PE samples prepared by USGS that are shipped to each laboratory for analysis. At present, the acceptance criteria for these samples have not been established.

Laboratory QA/QC for samples analyzed by PLM-Grav is maintained by laboratory-based QA/QC for the NIOSH 9002 PLM method requirements (specified by NVLAP). This includes daily evaluation of various blanks to check for contamination. No additional project specific QA/QC requirements have been established for this analytical method, to include interlaboratory and blank sample analysis.

### 2.22.3.4 Laboratory Quality Control Samples

This section discusses the laboratory QC samples specific to asbestos analysis of OU4 samples. Laboratory QC samples associated with other analytical parameters (e.g., metals, VOCs) are prepared and analyzed in accordance with nationally recognized or analytical method requirements, and their data are evaluated by qualified CDM staff on a case-by-case basis upon receipt of the laboratory data package.

Program-wide goals for laboratory TEM QC sample acceptance criteria are documented in LB-000029 and acceptance criteria for reanalysis samples are detailed in LB-000029b. These laboratory modifications can be revised (updated) as acceptance criteria are redefined.

***Laboratory Blanks***

Laboratory blanks are prepared from a new, unused filter at the laboratory and analyzed using the same procedure as used for field samples. If one or more asbestos structures are detected on a laboratory blank, the laboratory notifies the CDM laboratory coordinator and immediately takes steps to eliminate the source of contamination before analyzing any project samples.

*Re-Analysis Samples*

Re-analysis samples include recount same, recount different, verified analysis, and interlaboratory QA samples. These are defined as:

- Recount Same - field sample TEM grid that is reexamined by the same microscopist that performed the initial examination. The microscopist examines only the same grid openings that were counted in the original examination.

- Recount Different - field sample TEM grid that is reexamined by a different microscopist at the same laboratory than performed the initial examination. The microscopist examines only the same grid openings that were counted in the original examination.

- Verified Analysis - similar to a Recount Different, but has different requirements with regard to documentation. A verified analysis must be recorded in accordance with the protocol provided in NIST requirements.

- Interlaboratory Samples - field sample TEM grid that is reexamined by a different microscopist at a different laboratory than performed the initial examination. The microscopist examines only the same grid openings that were counted in the original examination.

Whenever a recount occurs in which one or more of the acceptance criteria are not met, the sample will undergo verified analysis. The senior laboratory analyst uses the results of the validated analysis to determine the basis of the discordance and takes appropriate corrective action (e.g., retraining in counting rules, quantification of size, identification of types). Each laboratory notifies the CDM laboratory coordinator of any significant exceptions or corrective action and documents all exceptions on a Laboratory Modification Form.

*Repreparation Samples*

Repreparation samples are field sample TEM grids prepared from a new aliquot of the original sample filter. Typically, this is done at the same laboratory that performed the original analysis; however, a different laboratory may also be requested to reprepare samples. If the repreparation is done within the same laboratory, the repreparation and reanalysis should be done by a different analyst than analyzed the original grid, whenever possible.

Repreparation samples are evaluated by comparing the total counts of the original and the repreparation samples. Acceptance criteria for this QC sample type are that the results must not be statistically different from each other at the 90 percent confidence interval, using the procedure documented in LB-000029b. If this acceptance criterion is not met, a senior analyst determines the basis for the discordant results, and if it is judged that the discordance is related to laboratory procedures, the laboratory takes appropriate corrective action.

*Drying Blanks*
Drying blanks are prepared from a new, unused filter at the laboratory and analyzed using the same procedure as used for the field samples, complying with LB-000055. When no asbestos is detected, the oven drying process is determined to be satisfactory and no cross-contamination is suspect. If asbestos structures are found, the laboratory immediately decontaminates the drying oven. Analytical data for the field samples associated with the contaminated drying blank requires evaluation to determine if analysis on the field samples should proceed and if the data set requires qualification.

*Method Blanks*
Method blanks are prepared from a new, unused filter at the laboratory and analyzed using the same indirect sample preparation procedure as that used on the associated field samples. Sample preparation is determined to be satisfactory and no cross-contamination is suspect when no asbestos is detected on a method blank. If asbestos structures are found, the laboratory immediately notifies the CDM laboratory coordinator to receive further direction. Analytical data for any samples associated with the method blank requires evaluation to determine if analysis on the field samples should proceed and if the data set requires qualification.

### 2.22.3.5 Laboratory Sample Custody and Handling

Laboratory custody procedures are provided in the laboratories' QA management plan, which were reviewed by CDM as part of the laboratory procurement process and were independently audited and found to be satisfactory by EPA's laboratory audit team.

In general, upon receipt at the laboratory, each sample shipment is inspected to assess the condition of the packaging/shipping and the integrity of the individual samples. The sample custodian cross-references the COC with the samples in the shipment and if any issues are found, contacts the sender for rectification. The sample custodian may next assign a unique laboratory number to each sample to identify the sample through all further handling at the laboratory. It is each laboratory's responsibility to maintain internal logbooks and records throughout sample preparation, analysis, and data reporting.

### 2.22.3.6 Laboratory Staff Training

Personnel performing analytical functions for Libby samples must read and understand all documents governing: laboratory operations, current analytical and project-specific method modifications, and applicable documents governing facility/personnel health and safety.

All analysts are trained to participate in the laboratory QA program. The entire program is discussed to ensure understanding of responsibility. The purpose of the program is explained and upon demonstration of testing proficiency, and each analyst is enrolled as an active participant in the program. This includes inter- and intra-laboratory testing. A training checklist or logbook is used to assure that specific tasks have all been completed satisfactorily. Key components of the laboratory staff training program are discussed below.

*Mentoring*

A team laboratory orientation/mentoring program was developed to facilitate new laboratories gaining the skills needed to perform reliable analyses for Libby samples. All new laboratories are required to participate in this program. The training program includes a rigorous 2-3 day period of onsite training provided by senior staff from those laboratories already under contract on the Libby project. The tutorial process includes a review of morphological, optical, chemical, and electron diffraction characteristics of LA, as well as training on project-specific analytical methodology, documentation, and administrative procedures used for Libby Site samples.

*Site-Specific Reference Materials*

Representative material provided by USGS, as well as previously analyzed field samples from Libby, is used during training. Prior to analyzing Libby field samples, each laboratory must successfully analyze multiple LA structures present in these samples by TEM to become familiar with its physical and chemical appearance, and to establish a reference library of LA energy dispersive spectroscopy spectra. The laboratory-specific and instrument-specific reference spectra collected during the laboratory training phase serves to guide the classification of particles observed in Libby field samples.

### 2.22.3.7 Laboratory Periodic Monitoring

An environmental monitoring program is required at each contracted asbestos analytical laboratory. Ambient air and dust samples are analyzed at the laboratory using TEM methods to check for asbestos and to ensure laboratory cleanliness. Facilities monitoring analytical results are provided to CDM for review. In addition, the onsite asbestos laboratory is independently monitored by EPA on a monthly basis during project operations, as discussed in Section 2.5.19. If any type of asbestos is observed at any level, the laboratory is cleaned and other necessary corrective action is taken to identify and remove the source of contamination. Specifics regarding the requirements of laboratory facilities monitoring are described in each laboratory's QA plan.

### 2.22.3.8 Laboratory Audits

As discussed in this section, several types of audits are performed to ensure high quality functioning of project laboratories. Copies of all audits reports and related documentation are maintained at the laboratory, and in CDM project files as applicable.

*External Audits*

Each laboratory working on the Libby project participated in an external onsite laboratory audit carried out by the EPA Superfund Analytical Services Branch. These audits were performed by EPA personnel or their contractors independent of the laboratory team members to: 1) ensure sufficient laboratory capacity to meet the needs of the Libby Site or other sites of Libby-related ore processing plants throughout the U.S.; and 2) ensure that the laboratory met basic capability and quality standards associated with analytical methods appropriate for any testing needs related to these sites.

The current overarching quality framework used by testing laboratories follows both NVLAP and AIHA checklists that are ISO method 17025:2005 compliant. During onsite audits that are performed by certifying inspectors who visit laboratories biannually, the inspectors review operations checklist items.

*Internal Audits*
Project laboratories conduct annual (or more frequent) internal audits using standard checklists. Audits are performed by a senior staff member, QA director, or representative from their corporate office. These audits may cover mechanical aspects such as microscope alignment, resolution, and field area determination, or QC aspects such as the successful reading of a known reference slide or sample reanalysis. The audit extends to document control, report generation and review, and data QA.

## 2.22.4 Modifications to Governing Documents

Modifications to documents governing OU4 field activities, soil sample preparation, and sample analysis were reviewed and approved by EPA and implemented by respective field, CSF, or laboratory personnel. All modifications were documented via the Libby Asbestos Project Record of Modification Form specific to the field, CSF, or laboratory activity being modified.

No negative implications or biases to data have been noted as a result of these modifications. Details regarding modifications to field governing documents are provided in the *Draft Data Collection Summary for OU4* (CDM 2009g); modifications to laboratory governing documents are described in the *Draft Analytical Methods Summary for OU4* (CDM 2009a) which are both provided in Appendix A. Modification forms related to CSF procedures are maintained by the CSF manager.

## 2.22.5 Achievement of Data Quality Objectives

Each guidance document referenced in this report describes the DQOs specific to each data collection event conducted at OU4. EPA's Technical Assistance Unit, in collaboration with the EPA OU4 remedial project manager and other project technical experts such as SRC, has assisted in determining these specific DQOs.

Data collected under the 1999 or 2000 Phase 1 QAPPs are under review by the EPA project team as part of the human health risk assessment; however, the general Phase 1 objectives were met. All other task-specific DQOs were met.

## 2.22.6 Data Usability

Data collected at OU4 were evaluated by the EPA On-Scene Coordinator (for emergency response data) or government contractors in consultation with EPA or Volpe Center representatives. As task-specific DQOs were met, OU4 data that have successfully been uploaded to the project database are considered usable and have been reported in this document.

# Section 3
# Physical Characteristics of the Study Area

The Libby Site encompasses an area of roughly 200 square miles ($mi^2$) centered around Libby, Montana. The City of Libby is concentrated in the valley formed by the Cabinet Mountain range and Kootenai River (Figure 1-4). The sections below describe in detail the physical characteristics of the Libby Site.

## 3.1 Physical Setting

Libby consists of a small "downtown" core with populated areas spreading in several directions, primarily along highways and stream valleys (Figure 1-3). Businesses are focused in the downtown core and along U.S. Highway 2 and Highway 37. The size and construction of typical residential and commercial structures in the area varies considerably, but there are numerous older buildings in various states of disrepair. Roughly 78 percent of residential properties were built prior to 1990 and 40 percent were built prior to 1960 (U.S. Census Bureau, 2004).

Local tax records and other information suggest there are approximately 4,000 individual residential, commercial, and public properties in the general Libby area (CDM 2006b). Property inspections by EPA indicate the presence of significant numbers of houses with "non-standard" construction, deteriorating conditions, and code violations. Most residential yards are grass covered and vegetated, but bare or thin areas are not uncommon.

Libby is situated along the Kootenai River, at the confluence of several smaller creeks, in a relatively narrow river valley. Mountains and National Forest surround the Libby valley on all sides: the Cabinet Mountains to the south, the Purcell Mountains to the north, and the Salish Mountains to the east. The elevation of Libby is approximately 2,000 feet above sea level. The area is primarily coniferous forest and heavily vegetated. provide the correct biome for the Libby Valley

### 3.1.1 Climate

Libby has a relatively moist climate, with annual precipitation in the valley averaging slightly over 20 inches (this includes approximately 60 inches of snowfall). Surrounding higher elevations receive significantly more precipitation. During the winter months, moist Pacific air masses generally dominate, serving to moderate temperatures and bring abundant humidity, rain, and snow. Colder, continental air masses occasionally drop temperatures significantly, but generally only for shorter periods. The average temperatures in December and January are 25 to 30 degrees Fahrenheit (°F).

During summer, the climate is warmer and dryer, with only occasional rain showers and significantly lower humidity and soil moistures. High temperatures of greater than 90°F are common. The average temperature in July is approximately 65 to 70°F. Spring and fall are transition periods.

Due to its valley location along the Kootenai River and downstream of the Libby dam, fog is common in the Libby valley. This effect is most pronounced during winter and in the mornings. Inversions, which trap stagnant air in the valley, are also common. Winds in the Libby valley are generally light, averaging approximately 6 to 7 miles per hour. Prevailing winds are from the west-northwest, but daily wind direction is significantly affected by temperature differences brought about by the large amount of vertical relief surrounding the area (Figure 1-4).

### 3.1.2 Surface Water Hydrology

The Libby valley and OU4 are contained within the Kootenai drainage basin and the Kootenai River and Fisher River sub-basins. The Kootenai drainage basin is contained in both Canada and the United States encompassing about 18,000 $mi^2$ or 11,520,000 acres.

The Kootenai River, which transects OU4 (Figure 1-3), has its origins in British Columbia's Kootenay National Park in Canada. From there, it flows 485 miles into northwest Montana and through the towns of Libby and Troy. From there, it flows into northern Idaho, then back into Canada and Kootenay Lake. Ultimately, it joins with the Columbia River. Seventeen miles north of Libby, the river is held back by Libby Dam, creating a 90-mile long reservoir called Lake Koocanusa which reaches into Canada (LibbyMT.com).

Major tributaries to the Kootenai River below Libby Dam include the Fisher River (838 $mi^2$; 485 average cubic feet per second [cfs]), the Yaak River (766 $mi^2$; and 888 average cfs) and the Moyie River (755 $mi^2$; 698 average cfs). Kootenai River tributaries are characteristically high-gradient mountain streams with bed material consisting of various mixtures of sand, gravel, rubble, boulders, and drifting amounts of clay and silt, predominantly of glacio-lacustrine origin. Fine materials, due to their instability during periods of high stream discharge, are continually abraded and redeposited as gravel bars, forming braided channels with alternating riffles and pools. Streamflow in unregulated tributaries generally peaks in May and June after the onset of snow melt, then declines to low flows from November through March. Flows also peak with rain-on-snow events. Kootenai Falls, a 200-foot-high waterfall and a natural fish-migration barrier, is located 11 miles downstream of Libby, Montana.

The Kootenai River is the second largest tributary to the Columbia River in terms of runoff volume, third in terms of drainage area. The major tributaries of the Kootenai River are the St. Mary, Bull Elk, Fisher, Yaak, Moyie, and Slocan Rivers. The Kootenai Basin is largely mountainous and dominated by three major ranges. The Rocky Mountain Range and its offshoot, the Flathead Range, constitute the eastern boundary; the Purcell Range roughly bisects it from north to south. The Selkirk and Cabinet ranges mark the western boundary. Elevations reach a maximum of about 12,000 feet with most summit elevations between 6,000 and 7,500 feet. Except for a few areas, the entire watershed is heavily forested (LibbyMT.com).

As previously stated, Libby has a relatively moist climate with annual valley precipitation slightly over 20 inches. Higher elevations receive significantly more precipitation and account for much of the creek flow. Seasonal fluctuations cause varying levels of runoff and creek flow. Typically, runoff is most significant in spring when snow at higher elevations begins to melt. Summer precipitation does occur; however, typical summer weather is hot and dry and creek flow is moderated by high elevation lakes.

### 3.1.3 Geology

The mountains surrounding Libby are generally composed of folded, faulted, and metamorphosed blocks of Precambrian sedimentary rocks and minor basaltic intrusions. Primary rock types are meta-sedimentary argillites, quartzites, and marbles (Ferreira et al. 1992).

Excluding vermiculite-related materials that may be present, XRD analyses by the USGS of shallow, subsurface soil from more than ten sites in the Libby area show that it is comprised of major (greater than 20 percent) quartz, minor (5-20 percent) muscovite (and/or illite) and albitic feldspar, trace (<5 percent) orthoclase, clinoclore, non-fibrous amphibole (likely magnesiohornblende), calcite, amorphous material (probably organic) and possible pyrite and hematite. Other minerals will be present at levels below 0.5 percent and are generally not detectable by routine XRD analysis. These mineral components represent the average components for the area and will vary to some extent depending on location and history. Surface soil contains the above components with the addition of more organic material (USGS 2002).

The vermiculite deposit located at Vermiculite Mountain, the source of LA, is located approximately 7 miles northwest of the Town of Libby in the Rainy Creek drainage. The vermiculite deposit specific to the Libby mine is classified as a deposit within a large ultramafic intrusion, such as pyroxenite plutons, which is zoned and cut by syenite or alkalic granite and by carbonatitic rock and pegmatite. The formation of vermiculite and asbestiform amphiboles in the Libby mine deposit have been assessed to be the result of the alteration of augite by high-temperature silica-rich solutions (USGS 2002).

hydrothermal

The Vermiculite Mountain deposit is contained within the Rainy Creek alkaline-ultramafic complex. The Rainy Creek complex is described as the upper portion of a hydrothermally altered alkalic igneous complex composed primarily of magnetite pyroxenite, biotite, pyroxenite, and biotititie. The original ultramafic body is an intrusion into the Precambrian Belt Series of northwestern Montana with a syenite body southwest of the adjacent to the altered pyroxenite and is associated with numerous syenite dikes that cut the pyroxenites.

### 3.1.4 Soil

Soil is largely derived from the pre-Cambrian rocks, which break down to form loamy soil composed of sand and silt with minor amounts of clay. The Libby valley is somewhat enriched in clays due to its river valley location, and the dense forest of the region contributes organic matter to the soil. Much of the original soil in the area now occupied by the Town of Libby has been modified by human activities. These include addition of vermiculite from the Rainy Creek Complex to the soil, reworking of the soil during construction, road building, railroad operations, gardening, processing of vermiculite (i.e., expansion), and other activities. Soil generally varies in color from tan to gray to black.

### 3.1.5 Hydrogeology

The Libby basin is hydrologically bound to the west by the pre-Cambrian bedrock, to the north by the Kootenai River and to the east by Libby Creek. The southern boundary of the basin extends under the high terrace of glacial lake bed sediments and with the alluvium of Libby Creek (Woodward-Clyde Consultants 1988).

The sediments overlying bedrock in the vicinity of the City of Libby are of glacial, glaciofluvial or alluvial origins. The Libby Site stratigraphy is characterized by lenses of interbedded units consisting of gravels, sands, and silty to clayey gravels and sands. These units are the result of numerous episodes of alluvial and glacial erosion and deposition. Types of depositional environments likely to have existed in the Libby valley include braided stream, overbank, splay, point bar, till, moraine, outwash, loess (aeolian), channel, and lucustrine. These environments moved in time and space, occurred contemporaneously, cancelled each other out (by erosion) and varied drastically in the level of energy and capacity to sort the available clastic material (Woodward-Clyde Consultants 1988).

### 3.1.6 Demography and Land Use

most recent census

Based on the most recent population estimates available, approximately 2,600 people reside within the city limits of Libby, and approximately ~~11,000~~ 12,600 people reside in the general area of Libby (zip code 59923), which includes the populated areas outside the city limits. Approximately 1,000 people reside within the city limits of Troy.

Some notable trends and statistics are:

**Age**. The median age of residents of Lincoln County is approximately 42 years which is higher than the median age for the state (38 years). Approximately 25 percent of residents are under the age of 18.

**Education**. Approximately 20 percent of Lincoln County residents 25 years or older do not have a high school diploma, as compared to the state average of 13 percent.

**Household Income**. The median household income in 2002 was approximately $28,000, among the lowest in Montana and far below the state average ($33,000). Approximately 14 percent of families live below the poverty level.

**Employment**. Unemployment in Lincoln County has stayed between 11 and 15 percent for several years. It is one of the highest in the state and is well above the 4 percent state average. The largest historic employers in Libby, the former vermiculite mine and the former Stimson Lumber Mill, have closed, resulting in the loss of hundreds of jobs over the past several decades.

**Stability**. Lincoln County's population is relatively stable. For instance, in 2000, nearly 18 percent of households reported living in the same housing unit since 1970. During a health screening conducted by ATSDR in 2000, roughly 74 percent of those surveyed reported living in Libby area for more than 15 years (ATSDR 2001).

# 3.2 Ecology

## 3.2.1 Terrestrial Animals

According to the United States Forest Service, the forested areas surrounding Libby have a great diversity of over 350 fish, mammals, birds, reptiles, and amphibians.

Even though there are a variety of animals present in the forested areas surrounding Libby, it is unlikely that many of these animals would be encountered in developed areas that are inhabited by humans and generally free of dense forests.

## 3.2.2 Terrestrial Plants

Libby and the surrounding area exhibit tree and grass plant species that are dominant within the Kootenai National Forest.

## 3.2.3 Presence of Threatened, Endangered, and Protected Species

Threatened, endangered, and protected species that have been observed within OU4 include grizzly bear, gray wolf, Canada lynx, and bald eagle (http://www.fs.fed.us/r1/kootenai/resources/wildlife/wildlife.shtml). All of these animals have either been observed or have a likely possibility to be encountered in areas of OU4.

While only about 30-40 grizzly bears exist on the surrounding Kootenai National Forest, these bears have been observed within areas of OU4. There are currently nine

wolf ?

packs (four breeding packs) using the Kootenai National Forest, partly within OU4, for all or part of their territories. The population of Canada lynx in the surrounding OU4 forest is currently being studied. Bald eagles have been seen throughout the Libby Site (http://www.fs.fed.us/r1/kootenai/resources/wildlife/wildlife.shtml).

# Section 4
# Nature and Extent of Contamination

This section summarizes the nature and extent of LA detected at OU4 and is organized to present results for each of the contaminated media of concern discussed in Section 2. Following a summary of the investigation and removal soil sample results, the data is reevaluated to exclude contamination addressed during the removals and presents data that represent the current status of OU4.

## 4.1 Potential Data Gaps

### 4.1.1 Uncharacterized Properties

As discussed in Section 2.4, the majority of properties were inspected as part of the CSS during the 2002 and 2003 field seasons; however, there was not sufficient time during that period to inspect every property in Libby. Between 2004 and 2006, CSS investigations were only performed on a limited basis, and there are approximately 450 properties requiring an initial contamination assessment. Additionally, approximately 400 properties refused participation in the CSS or were unable to be contacted after five attempts.

EPA is currently developing a database to spatially correlate each property in the Libby Site. However; there is currently insufficient data to represent uncharacterized properties within OU4.

### 4.1.2 Partially Characterized Properties

As EPA responds to ERS requests at properties without initial contamination assessments, only those areas of immediate concern are addressed. That is, a full indoor and outdoor CSS is not conducted at properties where a homeowner intends to remodel only a specific area. Instead, an inspection is performed to the extent that will allow the homeowner to safely execute their plans while mitigating risks of exposure and cross-contamination, and the remainder of the property will be inspected when full-scale contamination assessments are resumed.

An additional source of partially characterized properties stems from CSS inspections where the owners denied access to a portion of the property, usually the interior of the house. At the conclusion of the CSS, the attics of approximately 50 properties were not inspected at the owner's request or because the area was inaccessible.

### 4.1.3 Properties outside OU4 Boundary

As discussed in Section 1.4, the initial study area for OU4 was established in 2002 as a tool to guide sampling activities. As shown on Figure 2-23, properties within the boundary were the focus of investigations such as the CSS but a limited number of properties outside the established boundary have also been investigated. Investigations of properties outside the established boundary have generally been in response to homeowner inquiries or reports of contamination.

The majority of areas excluded from OU4 are undeveloped and uninhabited. However, two areas of the Libby valley that are well established are along U.S. Highway 2 and Pipe Creek Road. If EPA were to include the properties from the northern and southern proposed expansion areas as shown on Figure 4-1, approximately 550 properties would require a contamination assessment.

?

Are these just isolated residential structures

## 4.2 LA in Indoor Air

A total of 2,897 analytical results for indoor air samples are available from samples collected at 289 different properties from all the investigations described in Section 2. As the findings of the Phase 2 investigation determined (Section 2.3), personal and stationary air sample results can provide different results depending on the proximity to exposures and the magnitude of source material being disturbed. As a result, discussions regarding the nature and extent of LA in indoor air have been separated into discussion regarding personal air and stationary air.

Figure 2-12 shows the 176 properties where at least one indoor air sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern of detectable LA, either for the occurrence of LA in indoor air or for the level of LA reported in indoor air within OU4.

### 4.2.1 Personal Air

A total of 1,425 analytical results for indoor personal air samples are available. Each of the investigations under which the samples were collected is described in detail in Section 2. In general, the indoor personal air samples were collected to estimate exposures related to general indoor activities that included reading, watching television, general housework, remodeling activities, and active disturbance of vermiculite insulation. The activities performed during each investigation varied as described in Section 2. The following table summarizes the number of samples collected per investigation and the analytical results for the samples.

| Summary of Indoor Air Investigations – Personal Air Samples | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of Analyses | | | Total Number of Analyses per Investigation | Number of Analyses with Detections of LA | | Range of Concentrations Detected | |
| Investigation | PCM | TEM AHERA | TEM ISO | | PCM | AHERA and ISO | PCM (f/cc) | AHERA and ISO (s/cc) |
| Phase 2 | 280 | 41 | 430 | 751 | 222 | 128 | 0.001 to 1.819 | 0.00008 to 7.14 |
| Clean-Up Evaluation | 0 | 8 | 0 | 8 | -- | 1 | -- | 0.00015 |
| SQAPP | 0 | 0 | 24 | 24 | 0 | 15 | -- | 0.00013 to 0.00663 |
| Indoor ABS | 0 | 0 | 642 | 642 | 0 | 246 | -- | 0.00013 to 0.0497 |
| **Totals** | 280 | 49 | 1,096 | 1,425 | 222 | 390 | 0.001 to 1.819 | 0.00008 to 7.14 |

A total of 222 samples had detections of fibers ranging from 0.001 to 1.819 f/cc by PCM and 390 samples had detections of LA ranging from 0.00008 to 7.14 s/cc by TEM AHERA or TEM ISO.

### 4.2.2 Stationary Air Samples

A total of 1,472 analytical results for indoor stationary air samples are available. Each of the investigations under which the samples were collected is described in detail in Section 2. In general, the indoor stationary air samples were collected to investigate the following;

- Gain a general understanding of the concentration of LA in ambient air indoors (Phase 1 and School Investigation)
- Determine the possibility of using stationary air samples to estimate personal exposures (Phase 2)
- Determine the efficacy of cleanups (Cleanup Evaluation and SQAPP)

The activities performed during each investigation varied as described in Section 2. The following table summarizes the number of samples collected per investigation and the analytical results for the samples.

| Summary of Indoor Air Investigations – Stationary Air Samples | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of Analyses | | | Total Number of Analyses per Investigation | Number of Analyses with Detections of LA | | Range of Concentrations Detected | |
| Investigation | PCM | TEM AHERA | TEM ISO | | PCM | AHERA or ISO | PCM (f/cc) | AHERA or ISO (s/cc) |
| Phase 1 | 96 | 329 | 255 | 680 | 75 | 246 | 0.001 to 0.193 | 0.00025 to 0.5381 |
| Phase 2 | 215 | 5 | 408 | 628 | 115 | 300 | 0.002 to 1.129 | 0.00009 to 2.4043 |
| Clean-Up Evaluation | 0 | 68 | 0 | 68 | -- | 5 | -- | 0.00015 |
| SQAPP | 0 | 0 | 45 | 45 | -- | 32 | -- | 0.00005 to 0.00247 |
| School Investigation | 0 | 0 | 51 | 51 | -- | 2 | -- | 0.00052 to 0.00593 |
| **Totals** | 311 | 402 | 759 | 1,472 | 190 | 585 | 0.001 to 1.129 | 0.00005 to 2.4043 |

A total of 190 samples had detections of fibers ranging from 0.001 to 1.129 f/cc by PCM and 585 samples had detections of LA ranging from 0.00005 to 2.40 s/cc by TEM AHERA or TEM ISO.

## 4.3 LA in Outdoor Air

A total of 1,639 analytical results are available for outdoor air samples from samples collected at 117 different properties from all the investigations described in Section 2. As the findings of the Phase 2 investigation determined (Section 2.3), personal and stationary air sample results can provide different results depending on the proximity to exposures and the magnitude of source material being disturbed. As a result, discussions regarding the nature and extent of LA in outdoor air have been separated into discussion regarding personal air and stationary air and ambient air versus air near disturbed soil.

Figure 2-13 shows the 104 properties where at least one outdoor air sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in outdoor air or for the level of LA reported in outdoor air within OU4.

### 4.3.1 LA in Outdoor Ambient Air

A total of 804 analytical results for outdoor ambient air sample are available. Each of the investigations under which the samples were collected is described in detail in Section 2. In general, the outdoor ambient air samples were collected to estimate exposures related to general outdoor air. The following table summarizes the number of samples collected per investigation and the analytical results for the samples.

**Summary of Outdoor Ambient Air Investigations – Stationary Air Samples**

| Investigation | Number of Analyses | | | Total Number of Analyses per Investigation | Number of Analyses with Detections of LA | | Range of Concentrations Detected | |
|---|---|---|---|---|---|---|---|---|
| | PCM | TEM AHERA | TEM ISO | | PCM | AHERA or ISO | PCM (f/cc) | AHERA or ISO (s/cc) |
| Phase 1 | 46 | 6 | 87 | 139 | 2 | 9 | 0.002 to 0.003 | 0.00010 to 0.00168 |
| LCEH | 30 | -- | 46 | 76 | 29 | 5 | 0.001 to 0.034 | 0.00010 to 0.00086 |
| CSS Alley | -- | 30 | -- | 30 | -- | 3 | -- | 0.001 to 0.00095 |
| Ambient Air | --- | --- | 590 | 590 | --- | 79 | -- | 0.00004 to 0.00052 |
| **Totals** | 76 | 6 | 723 | 804 | 31 | 93 | 0.001 to 0.034 | 0.00004 to 0.00168 |

Of the 804 samples, 682 were non-detect for LA. A total of 31 samples had detections of fibers ranging from 0.001 to 0.034 f/cc by PCM and 93 samples had detections of LA ranging from 0.00004 to 0.00168 s/cc by TEM AHERA or TEM ISO. Figure 2-13 shows the 20 properties where at least one outdoor ambient air sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in outdoor ambient air or for the level of LA reported in outdoor ambient air within OU4.

The extent of LA in outdoor ambient air has been well studied within OU4. An additional air monitoring program is currently being planned to monitor outdoor air along routes used to transport material from properties that are being cleaned up to disposal locations at the Lincoln County Landfill and Rainey Creek Road.

## 4.3.2 LA in Outdoor Air Near Disturbed Soil

A total of 835 analytical results for outdoor air samples collected near disturbed soil are available. Each of the investigations under which the samples were collected is described in detail in Section 2. In general, the outdoor air near disturbed soil was collected to estimate exposures related to the inhalation of LA resulting from disturbing LA-containing soils. The following sections summarize the personal and stationary air results collected near disturbed soil.

### 4.3.2.1 Personal Air

A total of 637 analytical results for personal air samples collected near disturbed soil are available. Each of the investigations under which the samples were collected is described in detail in Section 2. The following table summarizes the number of samples collected per investigation and the analytical results for the samples.

| Summary of Outdoor Air Near Disturbed Soil Investigations – Personal Air Samples | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Investigation | Number of Analyses | | | Total Number of Analyses per Investigation | Number of Analyses with Detections of LA | | Range of Concentrations Detected | |
| | PCM | TEM AHERA | TEM ISO | | PCM | AHERA or ISO | PCM (f/cc) | AHERA or ISO (s/cc) |
| Phase 2 | 5 | 2 | 15 | 22 | 0 | 7 | -- | 0.00799 to 0.17253 |
| Outdoor ABS | -- | -- | 460 | 460 | -- | 319 | -- | 0.00046 to 57.906 |
| School ABS | -- | -- | 64 | 64 | -- | 5 | -- | 0.00223 to 0.03885 |
| SQAPP | -- | -- | 67 | 67 | -- | 38 | -- | 0.00085 to 1.3966 |
| EPA ORD | -- | -- | 24 | 24 | -- | 0 | -- | -- |
| **Totals** | 5 | 2 | 630 | 637 | 0 | 369 | -- | 0.00046 to 57.906 |

Of the 637 samples, 268 were non-detect for LA. A total of 369 samples had detections of LA ranging from 0.00046 to 57.906 s/cc by AHERA or ISO. Figure 2-13 shows the 84 properties where at least one outdoor air sample near disturbed soil (personal and stationary combined) was found to contain a detectable level of LA.

The extent of LA in personal air samples near disturbed soils has been well studied within OU4; however not all exposure pathways and receptor populations have been identified. As additional exposure pathways and receptor populations are identified, additional investigation activities may be necessary.

### 4.3.2.2 Stationary Air

A total of 198 analytical results for stationary air samples collected near disturbed soil are available. Each of the investigations under which the samples were collected is described in detail in Section 2. The following table summarizes the number of samples collected per investigation and the analytical results for the samples.

**Summary of Outdoor Air Near Disturbed Soil Investigations – Stationary Air Samples**

| Investigation | Number of Analyses | | | Total Number of Analyses per Investigation | Number of Analyses with Detections of LA | | Range of Concentrations Detected | |
|---|---|---|---|---|---|---|---|---|
| | PCM | TEM AHERA | TEM ISO | | PCM | AHERA or ISO | PCM (f/cc) | AHERA or ISO (s/cc) |
| Phase 1 | -- | 2 | -- | 2 | -- | 0 | -- | -- |
| Phase 2 | 44 | 6 | 56 | 106 | 9 | 7 | 0.002 to 0.032 | 0.00280 to 0.04017 |
| SQAPP | -- | -- | 90 | 90 | -- | 18 | -- | 0.00088 to 0.69280 |
| **Totals** | 44 | 8 | 146 | 198 | 9 | 25 | 0.002 to 0.032 | 0.00088 to 0.69280 |

Of the 198 samples, 167 were non-detect for LA. A total of 9 samples had detections of fibers ranging from 0.000 to 0.032 f/cc by PCM and 25 samples had detections of LA ranging from 0.00088 to 0.69280 s/cc by TEM AHERA or TEM ISO. Figure 2-13 shows the 84 properties where at least one outdoor air sample near disturbed soil (personal and stationary combined) was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in outdoor air near disturbed soil or for the level of LA reported in outdoor air near disturbed soil within OU4.

The extent of LA in outdoor air near disturbed soils has been well studied within OU4. As additional exposure pathways and receptor populations are identified, additional investigation activities may be necessary.

## 4.4 LA in Vermiculite Insulation

A total of 112 vermiculite insulation samples have been analyzed from 90 properties during all previous investigation activities conducted at OU4 (Section 2). The following table summarizes the number of samples collected per investigation and the analytical results.

| Summary of Vermiculite Insulation Investigations | | | |
|---|---|---|---|
| **Investigation** | **Number of Analyses** | **Number of Analyses with Detections of LA** | **Range of Total LA Concentrations Detected** |
| Phase 1 | 104 | 73 | <1% to 5% |
| Phase 2 | 8 | 7 | <1% |
| PDI | 0 | 2 | <1% |
| **Totals** | 112 | 82 | <1% to 5% |

Of the 112 samples, 31 were non-detect for LA. The remaining 82 samples had LA concentrations ranging from <1 to 5 percent. Figure 2-14 shows the 71 properties where at least one vermiculite insulation sample was found to contain a detectable level of LA.

Based on the results of the Phase 1 investigation, *Technical Memorandum 2, Occurrence of Asbestos in Libby Vermiculite Insulation* (SRC 2002b) (hereafter referred to as Tech Memo 2) was written to assess the reliability of the assumption that all samples of vermiculite insulation should be considered a potential source of asbestos fibers. The findings of Tech Memo 2 included the following:

- It is reasonable and appropriate to assume that vermiculite insulation at the Libby Site is a probable source of asbestos fibers, and that individual analysis of each sample for vermiculite insulation is not necessary or cost effective for making decisions regarding the potential risk from this material at the Libby Site.

- There is not a clear spatial pattern, either for the occurrence of vermiculite insulation or for the level of asbestos reported in the vermiculite insulation.

Because of the findings presented in Tech Memo 2, sampling vermiculite insulation for determining the concentration of LA is not required. Of the 3,628 properties inspected for the presence of vermiculite insulation, 700 were found to have vermiculite insulation in the attic or exposed in the living space. Additionally, information compiled from IFFs, SIICs and PCCs indicate 467 properties with vermiculite insulation in walls.

The extent of vermiculite insulation in accessible areas is not fully characterized in the OU4 study area because of the incompletely characterized properties discussed in Section 4.1. These properties will be investigated in the future so that the extent of any additional vermiculite insulation and/or required cleanup action can be determined.

The extent of vermiculite insulation in walls is not fully characterized in the OU4 study area because of the rationale presented above as well as the limitations of inspecting contained spaces. In following the removal criteria discussed in Section

2.17, accessible vermiculite insulation has been the focus of investigations, design activities, and removal actions. Intrusive methods (e.g., drilling, scoping) are seldom used to characterize vermiculite insulation in walls. Instead, outlet covers and electrical fixtures are temporarily removed to determine the extent of vermiculite insulation in walls. Therefore, the number of properties where vermiculite insulation is identified in walls may be underestimated. If walls or other contained spaces are breached causing releases of vermiculite insulation, property owners are encouraged to contact the ERS program to remove the insulation. In the future, breaches of contained areas will be addressed as part of the long-term operations and maintenance of the Libby Site.

## 4.5 LA in Bulk Materials

A total of 359 bulk material samples have been collected at OU4 from 80 properties during all previous investigation activities conducted at OU4 (Section 2). Samples of bulk material submitted for analysis have included, but are not limited to chinking, concrete, dryer lint, drywall, mortar, plaster and any other materials thought to contain vermiculite or LA. The following table summarizes the number of samples collected per investigation and analytical results.

| Summary of Bulk Material Investigations | | | |
|---|---|---|---|
| **Investigation** | **Number of Analyses** | **Number of Analyses with Detections of LA** | **Range of Total LA Concentrations Detected** |
| Phase 1 | 167 | 21 | <1% to 3% |
| Phase 2 | 4 | 2 | <1% |
| CSS | 1 | 0 | -- |
| Design | 187 | 59 | <1% to 3% |
| **Totals** | 359 | 82 | <1% to 3% |

Of the 359 samples, 277 were non-detect for LA. The remaining 82 samples were found to contain total LA concentrations ranging from <1 to 3 percent. The materials found to have LA concentrations >1 percent include plaster, mortar, and pipe wrap. Figure 2-15 shows the 27 properties where at least one bulk sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in bulk material or for the level of LA reported.

The extent of LA-containing bulk materials is not fully characterized in the OU4 study area. This is because of the incompletely characterized properties discussed in Section 4.1. These properties will be investigated in the future so that the extent of any additional LA-containing bulk material and/or required cleanup action can be determined.

# 4.6 LA in Indoor Dust

A total of 8,907 indoor dust samples have been analyzed from 1,616 properties during all previous investigation activities conducted at OU4 (Section 2). The following table summarizes the number of samples collected per investigation and the analytical results.

**Summary of Indoor Dust Investigations**

| Investigation | Number of Analyses | | Total Number of Analyses per Investigation | Number of Analyses with Detections of LA | Range of Total LA Concentrations Detected (s/cc) |
|---|---|---|---|---|---|
| | TEM AHERA | TEM ISO | | | |
| Phase 1 | 184 | 2,338 | 2,522 | 356 | 30 to 566,120 |
| Phase 2 | 1 | 64 | 65 | 29 | 20 to 32,268 |
| CSS | 1,986 | 25 | 2,011 | 171 | 44 to 264,285 |
| Clean-Up Evaluation | 32 | 0 | 32 | 0 | - |
| SQAPP | 48 | 12 | 60 | 19 | 4.1 to 1,585 |
| Indoor ABS | 0 | 337 | 337 | 10 | 6.3 to 79.9 |
| PDI | 3,356 | 524 | 3,880 | 236 | 30 to 113,224 |
| **Totals** | 5,607 | 3,300 | 8,907 | 821 | 4.1 to 566,120 |

Of the 8,907 samples, 8,149 were non-detect for LA. The remaining 821 samples were found to contain total LA concentrations ranging from 4.1 to 566,120 s/cc. Figure 2-11 shows the 468 properties where at least one dust sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in indoor dust or for the level of LA reported in indoor dust within OU4.

The extent of LA contamination in indoor dust has not been fully characterized within OU4 as dust sample collection ceased in 2007 due to the findings of the dust pilot study (Section 2.12).

# 4.7 LA in Soil

## 4.7.1 LA in Surface Soil

A total of 36,505 surface soil samples (collected between 0 and 3 inches bgs) have been analyzed from 3,482 properties during all previous investigation activities conducted at the site (Section 2). The following table summarizes the number of samples collected per investigation and the analytical results.

| Summary of Surface Soil Investigations | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Number of Analyses** | | | | | | |
| **Investigation** | **PLM 600** | **PLM 9002** | **PLM Grav** | **PLM VE** | **Total Number of Analyses Per Investigation** | **Number of Analyses with Detections of LA** | **Range of Concentrations Detected** |
| Phase 1 | 0 | 2,616 | 742 | 1,238 | 4,596 | 877 | trace to 70% |
| CSS | 84 | 406 | 8,643 | 13,214 | 22,347 | 1,220 | trace to 68% |
| SQAPP | 0 | 0 | 4 | 73 | 77 | 36 | trace to 1% |
| OU4 ABS | 0 | 0 | 159 | 470 | 629 | 99 | trace to 1% |
| School ABS | 0 | 0 | 23 | 74 | 97 | 36 | trace |
| PDI | 0 | 33 | 2,132 | 6,594 | 8,759 | 1,462 | trace to 10% |
| **Totals** | 84 | 3,055 | 11,703 | 21,663 | 36,505 | 3,730 | trace to 70% |

Of the 36,505 samples, 32,775 were non-detect for LA. The remaining 3,730 samples were found to contain total LA concentrations ranging from trace to 70 percent. Figure 2-9 shows the 1,091 properties where at least one surface soil sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in surface soil or for the level of LA reported.

However, the extent of LA containing surface soil is not fully characterized in the OU4 study area. This is because of the incompletely characterized properties discussed in Section 4.1. These properties will be investigated in the future so that the extent of any additional LA containing soil and/or required cleanup action can be determine.

### 4.7.2 LA in Subsurface Soil

A total of 8,163 subsurface soil samples (collected at a depth greater than 3 inches bgs) have been analyzed from 1,046 properties during all previous investigation activities conducted at the site (Section 2). Soil samples collected at depth as part of removal activities have also been included in this section as the majority of samples represent the final excavation depth. The following table summarizes the number of samples collected per investigation and the analytical results.

| Summary of Subsurface Soil Investigations | | | | | | |
|---|---|---|---|---|---|---|
| | **Number of Analyses** | | | | | |
| **Investigation** | **PLM 9002** | **PLM Grav** | **PLM VE** | **Total Number of Analyses Per Investigation** | **Number of Analyses with Detections of LA** | **Range of Concentrations Detected** |
| Phase 1 | 114 | 25 | 34 | 173 | 42 | trace to 10% |
| CSS | 5 | 52 | 76 | 133 | 11 | trace to <1% |
| PDI | 1 | 3 | 5 | 9 | 4 | trace to <1% |
| Removal | 7,658 | 61 | 112 | 7,831 | 1,413 | trace to 10% |
| Demo | 9 | 0 | 9 | 18 | 1 | <1% |
| **Totals** | 7,787 | 140 | 236 | 8,163 | 1,471 | trace to 10% |

Of the 8,163 samples, 6,692 were non-detect for LA. The remaining 1,471 samples were found to contain total LA concentrations ranging from trace to 10 percent. Figure 4-2 shows the 497 properties where at least one subsurface soil sample was found to contain a detectable level of LA. As can be seen there is not a clear spatial pattern, either for the occurrence of LA in subsurface soil or for the level of LA reported.

The extent of LA containing subsurface soil is not fully characterized in the OU4 study area as investigations to date have focused on surface soils as the main source of LA leading to exposures in soil. However, subsurface soils containing LA can be encountered when excavations are completed in the subsurface. EPA has developed the ERS program for when suspected contaminated soil is encountered under these circumstances.

## 4.8 LA in Water

A total of 31 water samples have been collected at OU4. Four were collected during the Phase 1 investigation and 27 from the Lincoln County Landfill as part of the semiannual groundwater monitoring activities.

Of the 31 samples collected, 29 were analyzed by EPA Method 100.2. Of these 29 samples, two were collected from water collected from a private drinking water well at a private residence (244 Vicks Drive), one from the kitchen faucet and the other from an outdoor spigot near the pump house. Both samples were non-detect for LA. The remaining 27 samples analyzed by 100.2 were collected from a groundwater monitoring well located at the Lincoln County Landfill. Of these 27 samples 3 had detections of LA ranging from 2.6E+06 to 8.8E+07 structures per liter with LA structure counts of 2 to 3.

The remaining two water samples were collected from a private drinking water well at a private residence (6700 Highway 37) and analyzed by TEM ISO. One sample collected from the well was non-detect for LA, and the other sample collected from a water hose detected one structure of LA (no LA concentration for this sample was reported).

This limited data set does not provide enough information to determine the nature and extent of LA in water within OU4, and additional investigation should be considered to adequately determine the nature and extent of LA in surface water, groundwater, and drinking water within OU4.

## 4.9 Summary of LA Remaining Post Removal

The following sections summarize the LA remaining at OU4 after the removal actions; at 1,202 property groups are considered. The following media were addressed during removal actions and have supporting clearance sample data to confirm the removal:

- Indoor removal actions remove accessible vermiculite insulation from attics and living spaces
- Indoor removal actions remove or encapsulate friable bulk materials
- Interior cleanings remove LA-contaminated indoor dust from areas where analytical results exceed 5,000 s/cm$^2$ or where vermiculite is observed in a living space
- Outdoor removal actions remove LA-contaminated surface soil (as detected by PLM)

In this section, a property where a removal action has been completed is referred to as "post removal." Partial removal actions are treated similarly to a property where no removal action has taken place.

### 4.9.1 Indoor Air

Although some properties with detectable levels of LA in indoor air samples have undergone a removal action, it is not possible at this time to estimate the remaining concentration of LA in indoor air based solely on the data of whether a removal action has been completed.

### 4.9.2 Outdoor Air

Although some properties with detectable levels of LA in outdoor air samples have undergone a removal action, it is not possible at this time to estimate the remaining concentration of LA in outdoor air based solely on the data of whether a removal action has been completed.

### 4.9.3 Vermiculite Insulation

Vermiculite insulation has been removed from the attic and/or living space of 596 property groups. The remaining 104 locations with vermiculite insulation in the attic or living space are shown on Figure 4-3. Many of these locations have undergone PDI activities and are in queue for future removal actions.

### 4.9.4 Bulk Materials

LA-containing bulk materials have been removed or encapsulated at 18 property groups. The remaining 8 locations with detectable levels of LA in bulk materials are shown on Figure 4-4.

### 4.9.5 Indoor Dust

All dust samples with detectable levels of LA have been removed during interior cleanings at 260 properties. The remaining 208 properties with detectable levels of LA in dust are shown on Figure 4-5. Although each property is only represented by one point on the figure, the highest concentration of LA for all dust samples was used to represent the remaining contamination at each property.

Properties where an interior cleaning occurred may continue to exhibit elevated dust sample results if the location of the interior cleaning differed from the area of dust sample collection. The majority of dust samples with detectable levels of LA are well below the action level of 5,000 s/cm$^2$. The 19 properties with at least one dust sample $\geq$ 5,000 s/cm$^2$ are in queue for future removal actions.

### 4.9.6 Surface Soil

LA-contaminated surface soil has been removed during outdoor removal actions at 631 properties. This number varies significantly from the number of outdoor removals and combination removals because some outdoor removals have been based solely on visible vermiculite. The remaining 460 properties with detectable levels of LA in surface soil are shown on Figure 4-6.

### 4.9.7 Subsurface Soil

Although a limited amount of LA-contaminated subsurface soil has been removed during outdoor removal actions, the collection of clearance soil samples increases the dataset of subsurface contamination. Because the clearance criteria allow for soils <1 percent LA to remain at depth, 466 properties have detectable levels of LA in subsurface soil post removal (Figure 4-7).

As described above, clearance soil samples involve sampling at progressively deeper intervals as analytical results indicate additional material requires removal. That is, many of the subsurface clearance soil samples with detectable levels of LA presented in Section 2.20.3 were removed after analytical results were received.

On occasion, when property-specific conditions did not allow for additional excavation to the prescribed maximum depth of 36 inches, subsurface soils may contain levels of LA ≥1 percent. The location of the 11 properties containing ≥1 percent LA in subsurface soils are shown on Figure 4-7.

### 4.9.8 Water

Although some properties with water samples have undergone a removal action, it is not possible at this time to estimate the remaining concentration of LA in water based solely on the data of whether a removal action has been completed.

# Section 5
# Summary and Conclusions

This section includes the summary and conclusions related to all data presented in this report and the associated appendices.

## 5.1 Summary

### 5.1.1 Background

The main contaminant of concern at the Libby Site is asbestos. The vermiculite deposit 7 miles northwest of Libby contains a distinct form of naturally-occurring amphibole asbestos that is comprised of a range of mineral types and morphologies. At the Libby Site, the form of asbestos that is present in the vermiculite deposit is amphibole asbestos that is referred to as LA. The term LA refers generally to amphibole materials that originated in the Libby vermiculite deposit, have the ability to form durable, long, and thin structures that are generally respirable, can reasonably be expected to cause disease, and hence are considered the contaminant of concern at the Libby Site.

The Libby vermiculite deposit was mined from the 1920s until 1990. The mine began limited operations in the 1920s and was operated on a larger scale by Grace from approximately 1963 to 1990. While the mine was in operation, it is estimated that the milling process released more than 5,000 pounds of asbestos into the atmosphere every day. In addition to contamination directly related to vermiculite processing operations, waste products and off-specification materials were made available to the general public on a large scale.

Vermiculite products and wastes were used in thousands of private residences, businesses, and public buildings across the Libby Site. Vermiculite insulation, both commercially purchased and/or obtained otherwise, was used at a high rate in Libby buildings. In the course of Superfund investigations, EPA has encountered vermiculite used as an additive in mortar, plaster, and concrete; as insulation in attic and walls; in soils at depth around septic tanks, tree roots, underground pipe trenches, building foundations; and in surface soils in gardens, yards, driveways, and play areas.

### 5.1.2 Investigations

In November 1999, EPA responded to requests from the State of Montana, Lincoln County Health Board to investigate the potential exposure to asbestos related to the former mine operations and vermiculite processing. These initial investigations revealed two significant findings:

- There are a large number of current and historic cases of asbestos related diseases centered around Libby, Montana.
- The likelihood is high that significant amounts of asbestos-contaminated vermiculite still remained in and around Libby.

These findings led EPA to initiate a larger scale rapid investigation in December 1999 (Phase 1 investigation discussed in Section 2.2) to meet the following goals:

- Obtain information on airborne asbestos levels in Libby in order to judge whether time-critical intervention is needed to protect public health.
- Obtain data on asbestos levels in potential source materials (at the Export Plant and Screening Plant), and identify the most appropriate analytical methods to screen and quantify asbestos in source materials.

Additional investigations, detailed in Section 2, from 2000 to today have been conducted to determine the nature and extent of LA and vermiculite source materials in OU4. LA has been observed in all media investigated. Within OU4 the location of LA and LA containing source materials do not appear to have a spatial pattern for distribution of location observed or concentrations of LA found within the source material. The table below summarizes the concentrations of LA observed across all media sampled.

**Summary of Pre-Removal LA Results Per Media**

| Media | Total Number of Analyses | Total Number of Analyses with LA | Percentage of Analyses with LA Observed (%) | Range of LA Results |
|---|---|---|---|---|
| Indoor Air – Stationary | 1,472 | 585 | 39.5 | 0.00005 to 2.4043 s/cc |
| Indoor Air – Personal | 1,425 | 390 | 27.4 | 0.00008 to 7.14 s/cc |
| Indoor Dust | 8,970 | 821 | 9.2 | 4.1 to 566,120 s/cm$^2$ |
| Outdoor Ambient Air | 804 | 93 | 11.6 | 0.00004 to 0.00168 s/cc |
| Outdoor Air Near Disturbed Soil – Stationary | 198 | 25 | 12.6 | 0.00088 to 0.69280 s/cc |
| Outdoor Air Near Disturbed Soil - Personal | 637 | 369 | 57.9 | 0.00046 to 57.906 s/cc |
| Bulk Materials | 359 | 82 | 23.7 | <1% to 3% |
| Vermiculite Insulation | 112 | 82 | 73.2 | <1% to 5% |
| Water | 31 | 4 | 12.9 | 2.6E+06 to 8.8E+07 s/L |
| Surface Soil | 36,505 | 3,730 | 10.2 | trace to 70% |
| Subsurface Soil | 8,168 | 1,471 | 18.0 | trace to 10% |

Notes: LA – Libby amphibole; % – percent; ND – non-detect; s/cc – structures per cubic centimeter; s/cm$^2$ – structures per square centimeter; < – less than; s/L – structures per liter

### 5.1.3 Property Category Status

As of December 2009, 3,628 OU4 properties have been investigated. Based on the three removal planning categories and the criteria outlined in the table at the beginning of Section 2.17, these properties fall into the following categories:

- 1,735 total properties were categorized as Requiring Cleanup (i.e., exhibited at least one current removal action level trigger) in an indoor or outdoor location of concern.

- 776 properties were categorized as Additional Information Needed (i.e., conditions suggest potential contamination, but did not meet the current removal action levels). The 776 properties generally fall into the following subcategories: 248 properties have trace or <1 percent LA in soil; 432 properties have secondary indicators; 95 properties have visible vermiculite in a NSUA; and 1 property has a course fraction soil sample result $\geq$1 percent LA.

- 1,117 were categorized as Cleanup Not Likely Required (i.e., no emergency response triggers or other conditions suggesting contamination was observed or detected).

The location and remediation status of these properties are shown on Figure 2-23. These numbers are based on the visual presence of vermiculite in an attic, living space, SUA or NSUA as documented on the IFF during the CSS and combined with the analytical results for soil and dust samples collected during Phase 1, CSS, Post Cleanup Evaluation, SQAPP, PDI, and residential ABS. It is important to reiterate that prior to Fall 2006, no formalized approach to inspect or quantify vermiculite in soil existed.

### 5.1.4 Cleanup Status

Between 2001 and December 31, 2009, a total of 1,202 property groups have been completed. The following table shows the total amount of removals, by removal type.

| Type of Removal Activity | Number of Property Groups |
|---|---|
| Indoor | 212 |
| Outdoor | 489 |
| Combination (e.g., Indoor and Outdoor or Outdoor and Demolition) | 501 |

The status of the remaining properties currently known to contain at least one LA contaminant source material is summarized below:

- Vermiculite insulation has been removed from the attic and/or living space of 596 property groups. There are 104 locations remaining with vermiculite insulation in the attic or living space (Figure 4-3).

- **LA-containing bulk materials** have been removed or encapsulated at 18 property groups. There are 8 locations remaining with detectable levels of LA in bulk materials (Figure 4-4).

- **LA-contaminated indoor dust** samples have been removed during interior cleanings at 260 properties. There are 208 properties remaining with detectable levels of LA (Figure 4-5). The majority of dust samples with detectable levels of LA are well below the action level of 5,000 $s/cm^2$. The 19 properties with at least one dust sample $\geq$ 5,000 $s/cm^2$ are in queue for future removal actions.

- **LA-contaminated surface soil** has been removed during outdoor removal actions at 631 properties. This number varies significantly from the number of outdoor removals and combination removals because some outdoor removals have been based solely on visible vermiculite. There are 460 properties remaining with detectable levels of LA in surface soil (Figure 4-6).

- Although a limited number of **LA-contaminated subsurface soils** have been removed during outdoor removal actions, the collection of clearance soil samples increases the dataset of subsurface contamination. Because the clearance criteria allow for soils <1 percent LA to remain at depth, 466 properties have detectable levels of LA in subsurface soil post removal (Figure 4-7). On occasion, when property-specific conditions did not allow for additional excavation to the prescribed maximum depth of 36 inches, subsurface soils may contain levels of LA >1 percent. The location of the 11 properties containing >1 percent LA in subsurface soils are shown on Figure 4-7.

### 5.1.5 Potential Data Gaps

- **Uncharacterized Properties** - There are approximately 450 properties requiring an initial contamination assessment within the current OU4 boundary and an additional 400 properties that refused participation in the CSS or were unable to be contacted.

- **Partially Characterized Properties** -

  1) As EPA responds to ERS requests at properties without initial contamination assessments, only those areas of immediate concern are addressed. That is, a full indoor and outdoor CSS is not conducted at properties where a homeowner intends to remodel only a specific area. Instead, an inspection is performed to the extent that will allow the homeowner to safely execute their plans while mitigating risks of exposure and cross-contamination, and the remainder of the property will be inspected when full-scale contamination assessments are resumed.

investigated. Investigations of properties outside the established boundary have generally been in response to homeowner inquiries or reports of contamination.

The majority of areas excluded from OU4 are undeveloped and uninhabited. However, two areas of the Libby valley that are well established are along U.S. Highway 2 and Pipe Creek Road. If EPA were to include the properties from the northern and southern proposed expansion areas as shown on Figure 4-1, approximately 550 properties would require a contamination assessment.

In or out?

## 5.2 Conclusions

Based on the information currently available and presented in this RI, the following conclusions have been drawn regarding OU4:

- LA has been observed in every media sampled at the site. Conclusions regarding risk associated with the levels observed will be provided in a risk assessment to be completed separate from this RI report.
- The nature and extent of LA contamination in water (surface, drinking, and groundwater) is not known due to the limited data set.
- 3,628 OU4 properties have been investigated. Per the 2003 Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum (EPA 2003c) these properties were placed in the following categories:
  - 1,735 total properties were categorized as Requiring Cleanup (i.e., exhibited at least one current removal action level trigger) in an indoor or outdoor location of concern.
  - 776 properties were categorized as Additional Information Needed (i.e., conditions suggest potential contamination, but did not meet the current removal action levels). Final determinations regarding the requirement of cleanup at these properties are required.
  - 1,117 were categorized as Cleanup Not Likely Required (i.e., no emergency response triggers or other conditions suggesting contamination was observed or detected). As Action Levels are modified (e.g., removal of visible vermiculite), additional investigation at these properties will be necessary as there was not a formalized approach to inspect or quantify vermiculite in soil prior to Fall 2006.
- A total of approximately 850 properties remain to be investigated within the current OU4 boundary.
- 1,202 property groups have been cleaned, with an additional 533 currently known to require removal actions based on the 2003 Action Memo (EPA 2003c).

2) An additional source of partially characterized properties stems from CSS inspections where the owners denied access to a portion of the property, usually the interior of the house. At the conclusion of the CSS, the attics of approximately 50 properties were not inspected at the owner's request or because the area was inaccessible.

- **Visible Vermiculite in Soils -** Properties were inspected for visible vermiculite during the CSS, before a formalized approach for identification and quantification of vermiculite in soils was implemented at the Libby Site. Beginning in fall 2006, inspections for visible vermiculite were standardized by implementing CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties.*

  Visible vermiculite inspections have mainly been implemented at the PDI stage, but other investigations beginning in 2007 or later have also utilized this approach at a limited number of properties. Because the vermiculite observed at the PDI stage is subsequently removed during the outdoor removal action, very limited data is available on the nature and extent of vermiculite in outdoor soils that remains at OU4 properties.

- **LA in Soils -** As seen in the SQAPP and ABS datasets, respirable LA fibers are released by disturbing soil where LA was not detected by PLM-VE. At the time of this report, research is underway to identify another analytical method capable of detecting LA at lower sensitivities (e.g., glove box, fluidized bed).

- **LA in Indoor Dust** - Although a measurable correlation between indoor dust and indoor air has not been established, 124 dust samples (collected from 82 properties) have detected LA at concentrations $\geq$ 5,000 s/cm$^2$. Dust samples were evaluated in the 2007 pilot study (Section 2.12), but LA was only detected at low concentrations and sample results were unable to be reproduced. These data suggest LA in indoor dust may be a data gap at OU4 in assessing exposure pathways and that sample collection techniques may require reevaluation.

  Additionally, indoor dust data are not available for each property at OU4. During the CSS, dust samples were only collected from properties where LA sources and/or if secondary indicators (e.g., former mine worker) were present. If dust sample data was insufficient to characterize a property's interior, additional samples were collected at the PDI phase. In total, dust samples have been analyzed for a total of 1,616 properties across all investigations and design activities. As discussed in Section 2.4.2, dust samples from an additional 271 properties have been archived indefinitely. Dust sample collection was stopped in 2007 after the results of the dust pilot study were evaluated.

- **Properties Outside Current OU4 Boundary** - The initial study area for OU4 was established in 2002 as a tool to guide sampling activities. As shown on Figure 2-23, properties within the boundary were the focus of investigations such as the CSS but a limited number of properties outside the established boundary have also been

# Section 6 References

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Amandus, H.E., and Wheeler, R. 1987. The Morbidity and Mortality of Vermiculite Miners and Millers Exposed to Tremolite-Actinolite: Part II. Mortality. Am. J. Ind. Med. 11:15-26.

Amandus, H.E., Wheeler, P.E., Jankovic, J., and Tucker, J. 1987. The Morbidity and Mortality of Vermiculite Miners and Millers Exposed to Tremolite-Actinolite: Part I. Exposure Estimates. Am J Ind. Med 11:1-14.

ASTM. 1995. ASTM D5755-95. Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations. October.

_____. 2003. ASTM D5755-03. Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by TEM for Asbestos Structure Number Concentrations. June.

ASTDR. 2001. Year 2000 Medical Testing of Individuals Potentially Exposed to Asbestiform Minerals Associated with Vermiculite in Libby, Montana. August 23. A Report to the Community.

_____. 2002a. Review of Asbestos-Related Abnormalities Among a Group of Patients from Libby, Montana. August.

_____. 2002b. Mortality in Libby, Montana, 1979 to 1998. August 8.

_____. 2003. Public Health Assessment for the Libby Asbestos NPL Site. May 15.

Berman, D.W., Crump, K.S., Chatfield, E.J., Davis J.M.G., and Jones, A. 1995. The Sizes, Shapes, and Mineralogy of Asbestos Structures that Induce Lung Tumors or Mesothelioma in AF/HAN Rats Following Inhalation. *Risk Analysis* 15/2/181-195.

CARB. 1991. Determination of Asbestos Content of Serpentine Aggregate. June 6.

CDM. 2000. Removal Action Sampling and Analysis Plan for Confirmation Soil Sampling of Soil and Perimeter and Personal Sampling of Air for Asbestos. September.

_____. 2001. Final Removal Action Work Plan for Kootenai Bluff Property. August 14.

_____. 2002a. Final Sampling and Analysis Plan, Remedial Investigation, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. April.

_____. 2002b. Final Sampling and Analysis Plan Addendum for the Cemetery Park Ball Fields. July.

_____.2002c. Final Sampling and Analysis Plan Addendum for the Libby Drive-In Theater. September.

_____. 2002d. Property-Specific Sampling and Analysis Plan for Air and Dust Sampling for Stimson Lumber Company, Libby Asbestos Project. August 23.

_____. 2003a. Final Sampling and Analysis Plan, Remedial Investigation, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. Revision 1. May 16.

_____. 2003b. Final Sampling and Analysis Plan, Remedial Investigation. May 19.

_____. 2003c. Final Draft Response Action Work Plan, Libby Asbestos Project, Libby, Montana. November.

_____. 2003d. Final Sampling and Analysis Plan Addendum for J. Neils Park and State Highway 37, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. July.

_____. 2003e. Final Sampling and Analysis Plan Addendum for the City of Libby Alley Investigation, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. October 14.

_____. 2003f. Final Sampling and Analysis Plan Addendum, Post Cleanup Evaluation Sampling, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2003g. Final Draft Pre-Design Inspection Activities Work Plan. November.

_____. 2003h. Final Dust Sampling Protocol for Pre-Design Investigations, Libby Asbestos Project. November.

_____. 2004a. Final Sampling and Analysis Plan Addendum for the Cabinet View Country Club, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. August 16.

_____. 2004b. Compost Stockpile Area Sampling Memorandum, Lincoln County Landfill, Libby, Montana. September 16.

_____. 2004c. Final Post Cleanup Evaluation Sampling Technical Memorandum, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. September.

_____. 2004d. Draft Final Ambient and Perimeter Air Monitoring Summary for the Period 2000–2003 Technical Memorandum, Libby, Montana. May.

_____. 2004e. Close Support Facility Soil Preparation Plan, Revision 1, Libby, Montana Asbestos Project, Sample Processing. March.

_____.2005a. Final Summary Report for the Cemetery Park Ball Fields, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. November.

_____. 2005b. Final Summary Report for the Libby Drive-In Theater, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2005c. Final Summary Report for the Cabinet View Country Club, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. April 21.

_____. 2005d. Final Summary Report for the J. Neils Park and Montana State Highway 37 Investigations, Revision 1, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. November.

_____. 2005e. Final Summary Report for the City of Libby Alley Investigation, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. November.

_____. 2005f. Johnston Acres Field Investigation Memorandum. January 7.

_____. 2005g. Draft Summary Report for the Johnston Acres Field Investigation. August.

_____. 2005h. Draft Sampling and Analysis Plan Addendum for the Former Concrete Plant Investigation, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2005i. Draft Sampling and Analysis Plan Addendum for the Former Landfill Site Investigation, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2005j. Small Scale Vermiculite Removal Memorandum. April 12.

_____. 2005k. CDM Oversight Activities Conducted at the St. John's Hospital Helipad Property in Libby, Montana Memorandum. December 16.

_____. 2006a. Comprehensive Site Health and Safety Program, Libby, Montana, Revision 5. December.

_____. 2006b. Contaminant Screening Study, Final Technical Memorandum, Libby Asbestos Site, Operable Unit 4, Libby, Montana. January 31.

_____.2006c. Draft Summary Report for the St. John's Lutheran Hospital Rehabilitation Center and Helipad Field, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. February.

_____. 2006d. Final Sampling and Analysis Plan for Outdoor Ambient Air Monitoring at the Libby Asbestos Site, Operable Unit 4, Libby, Montana. September 28.

_____. 2006e. Final Sampling and Analysis Plan for Outdoor Ambient Air Monitoring at the Libby Asbestos Site, Revision 1, Operable Unit 4, Libby, Montana. December 7.

_____. 2007a. Dust Composite Sampling Pilot Study, Libby Asbestos Project. May 16.

_____. 2007b. Response Action Work Plan, Revision 1, Libby Asbestos Project, Libby, Montana. April

_____.2008a. Lincoln County Class IV Asbestos Landfill Operations Plan, Revision 2. February.

_____. 2008b. Final Data Summary Report for Operable Unit 2, Former Screening Plant and Surrounding Area. May 13.

_____. 2008c. Final Technical Memorandum, Libby Public School Inspection, Libby, Montana. June 17.

_____. 2008d. Libby Schools Visual Vermiculite Investigation Summary Memorandum. July 28.

_____. 2008e. Final Sampling and Analysis Plan for Libby Public Schools - Stationary Air Sample Collection. December.

_____. 2008f. Response Action Work Plan, Revision 2, with modification, Libby Asbestos Project, Libby, Montana. February.

_____. 2009a. Analytical Methods Summary for Samples Collected at Operable Unit 4 of the Libby Asbestos Superfund Site. August 31. *In review.*

_____. 2009b. Wise Property and Kootenai Bluffs Subdivision Technical Sampling Memorandum. July 2.

_____. 2009c. Wise Property and Kootenai Bluffs Subdivision Summary Memorandum. September 4.

_____. 2009d. Libby Public Schools - Stationary Air Sampling Investigation Summary Memorandum. May 15.

_____. 2009e. Final Sampling and Analysis Plan for Activity-Based Outdoor Air Exposures at Libby Public Schools. July 17.

_____. 2009f. Environmental Resource Specialist Plan, Libby Asbestos Project. April.

_____. 2009g. Draft Data Collection Summary for Samples Collected at Operable Unit 4 of the Libby Asbestos Superfund Site. August 31. *In review.*

EPA. 1987. Appendix A to Subpart E of 40 CFR Part 763. Interim TEM Analytical Methods - Mandatory and Nonmandatory - and Mandatory Section to Determine Completion of Response Actions (AHERA). Final Register 52:41857. October 30.

_____. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response Compensation and Liability Act, Interim Final. Office of Solid Waste and Emergency Response Directive 9355.3-01. EPA/540/G-89/004. October.

_____. 1993. Method for the Determination of Asbestos in Bulk Building Materials. EPA/600-R-93/116. July.

_____. 1994. EPA 100.2. Determination of Asbestos Structures Over 10mm in Length in Drinking Water. June.

_____. 1999. Sampling and Quality Assurance Project Plan for Libby, Montana Environmental Monitoring for Asbestos (*Phase 1 QAPP*). December 6.

_____. 2000a. Action Memorandum: Request for a Time Critical Removal Action Approval and Exemption from the 12-month, $2-million Statutory Limit at the Libby Asbestos Site- Export Plant and Screening Plant former Processing Areas, Libby, Lincoln County, Montana. May 23.

_____. 2000b. Sampling and Quality Assurance Project Plan, Revision 1, for Libby, Montana Environmental Monitoring for Asbestos (*Phase 1 QAPP*). January 4.

_____. 2001a. Action Memorandum Amendment: Request for headquarters approval of a ceiling increase beyond $6 million and a modification to the proposed scope of response for the Time-Critical Removal Action at the Libby Asbestos Site - Libby, Lincoln County, Montana. July 20.

_____. 2001b. Phase 2 Sampling and Quality Assurance Project Plan for Libby, Montana. Environmental Monitoring for Asbestos. Evaluation of Exposure to Airborne Asbestos Fibers During Routine and Special Activities. March 1.

_____. 2002a. Action Memorandum Amendment for the Time Critical Removal Action at the Libby Asbestos Site - Libby, Lincoln County, Montana. May 2.

_____. 2002b. Sampling and Quality Assurance Project Plan for Measurement of Historic Fiber Deposition Rates in Sediment.

_____.2003a. Quality Assurance Project Plan, Performance Evaluation Study for Analytical Methods in Soil, Part B, Revision 1. January 24.

_____. 2003b. Sampling and Analysis Plan for Indoor Dust for Use at the Libby, Montana Superfund Site. August 7.

_____. 2003c. Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum. December 15.

_____. 2005a. Pilot Study Design, Effect of Ashing on Analysis of Indoor Dust for Asbestos. February 22.

_____. 2005b. Final Supplemental Remedial Investigation Quality Assurance Project Plan. June 24.

_____. 2005c. Sampling and Analysis Plan for Cumulative Inhalation Exposures in Libby, Montana. November 7.

_____. 2005d. General Sampling and Analysis Plan for Assessing Asbestos Release from Building Demolition at the Libby, Montana Superfund Site. May 4.

_____. 2006a. Action Memorandum Amendment Requesting Formal Approval of a Ceiling Increase for the Time-Critical Removal Action at the Libby Asbestos Site - Libby, Lincoln County, Montana. May 15.

_____. 2006b. Action Memorandum Amendment for a Time-Critical Removal Action at the Libby Asbestos Site, OU7, Troy, Montana. June 27.

_____. 2006c. Phase 2 Study Data Summary Report, Draft. March.

_____. 2007a. Summary Report for Data Collected under the Supplemental Remedial Investigation Quality Assurance Project Plan. October.

_____. 2007b. Sampling and Analysis Plan for Activity-Based Indoor Air Exposures, Operable Unit 4, Libby, Montana, Superfund Site. July 6.

_____. 2007c. Sampling and Analysis Plan for Activity-Based Outdoor Air Exposures, Operable Unit 4, Libby, Montana, Superfund Site. July 6.

_____. 2007d. General Workplan for Building Demolition at the Libby, Montana, Superfund Site, Revision 2. May 17.

_____. 2008a. Action Memorandum Amendment Requesting Approval to Address Amphibole Asbestos Contamination in Libby Creeks for the Time-Critical Removal Action at the Libby, Montana Superfund Site. September 24.

_____. 2008b. Study Design to Pilot Reconnaissance Activities for the Characterization of Geological Sources of Libby Amphibole in Libby Valley Soils. June 9.

_____. 2009a. Action Memorandum Amendment Request: Approval of a Ceiling Increase for the Time-Critical Removal Action at the Libby Asbestos Site - Libby, Lincoln County, Montana. June 17.

_____. 2009b. Action Memorandum Amendment Requesting Approval to Address Amphibole Asbestos Contamination at the Cabinet View Country Club Golf Course for the Time-Critical Removal Action at the Libby Asbestos Site - Libby, Lincoln County, Montana. August 4.

_____. 2009c. Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Site, Libby, Montana. October 2006 to June 2008. February 9.

_____. 2009d. Quality Assurance Project Plan: Phase 2 – Evaluation of the Aerosolization of Asbestos and Related Fibers from Bulk Materials. November 4.

Ferreira et al. 1992. Ferreira, R.F., Adams, D.B., Davis R.E. USGS Water Resources Investigation #91-4134, Development of thermal models for Hungry Horse Reservoir and Lake Koocanusa, Northwestern Montana and British Columbia.

ISO. 1995. ISO 10312:1999(E). Ambient Air - Determination of Asbestos Fibers - Direct Transfer TEM Method. May 1.

Leake BE, Woolley AR, Arps CES, Birch WD, Gilbert MC, Grice JD, Hawthorne FC, Kato A, Kisch HJ, Krivovichev VG, Linthout K, laird J, Mandarino JA, Maresch WV, Nickel EH, Rock NMS, Schumacher JC, Smith DC, Stephenson NCN, Ungaretti L, Whittaker EJW, Youzhi G. 1997. Nomenclature of the amphiboles: Report of the subcommittee on amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral names. American Mineralogist 82:1019-1037.

LibbyMT.com. 2007. Libby, Montana and Kootenai River Country, Kootenai River. Accessed at: http://www.libbymt.com/areaattractions/kootenairiver.htm, on December 10, 2007.

MacDonald, J.C., McDonald, A.D., Armstrong, B., and Sebastien, P. 1986. Cohort Study of Mortality of Vermiculite Miners Exposed to Tremolite. Brit. J. Ind. Med 43:436-444.

Meeker GP, Bern AM, Brownfield IK, Lowers HA, Sutley SJ, Hoeffen TM, Vance JS. 2003. The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. American Mineralogist 88:1955-1969.

NIOSH. 1994a. PCM NIOSH 7400(a), Issue 2. Asbestos and Other Fibers by PCM. August 15.

NIOSH. 1994b. PLM NIOSH 9002, Issue 2. Asbestos (bulk) by PLM. August 15.

Peipins LA, Lewin M, Campolucci S, Lybarger JA, Miller A, Middleton D, et al. 2003. Radiographic Abnormalities and Exposure to Asbestos-Contaminated Vermiculite in the Community of Libby, Montana, USA. Environ. Health Perspect. 111:1753-1759.

Rohs AM, Lockey JE, Dunning KK, Shulka R, Fan H, Hilbert T, Borton E, Wiot J, Meyer C, Shipley RT, LeMasters GK, Kapol V. 2007. Low level Fiber Induced Radiographic Changes Caused by Libby Vermiculite: A 25 year Follow-up Study. Am J Respiratory and Critical Care Medicine.

SRC. 2002a. SRC-LIBBY-01. Qualitative Estimation of Asbestos in Coarse Soil by Visual Examination Using Stereomicroscopy and Polarized Light Microscopy. November 12. Revision 1 dated May 20, 2003. Revision 2 dated April 21, 2004.

____. 2002b. Technical Memorandum 2, Occurrence of Asbestos in Libby Vermiculite Insulation. May 16.

_____. 2003. SRC-LIBBY-03. Analysis of Asbestos Fibers in Soil by Polarized Light Microscopy. March 3. Revision 1 dated December 11, 2003. Revision 2 dated October 10, 2008.

_____. 2004. SRC-DUST-01. High Volume Indoor Dust Sampling at Residences for Determination of Risk-Based Exposure to Metals. April 1.

_____. 2007a. ISSI-LIBBY-01, Standard Operating Procedure for Soil Sample Preparation, Revision 10. December 6.

_____. 2007b. Draft Quality Assurance and Quality Control Summary Report for the Libby Asbestos Superfund Site, Libby, Montana. *In review.* July 11.

Sullivan PA. 2007. Vermiculite, Respiratory Disease and Asbestos Exposure in Libby, Montana: Update of a Cohort Mortality Study. Environmental Health Perspectives doi:10.1289/ehp.9481 available online at http://dx.doi.org.

United States Census Bureau. 2004. Census 2000 Information. Accessed at quickfacts.census.gov, released July 2004.

USGS. 2002. Reconnaissance Study of the Geology of U.S. Vermiculite Deposits – Are Asbestos Mineral Common Constituents? USGS Survey Bulletin 2192, Version 1.0. May 7.

Woodward-Clyde Consultants. 1988. Phase IV, Step 3 Remedial Investigation Report. Libby, Montana Groundwater Contamination Site. April 1988. Prepared for Champion International Stamford, CT by Woodward-Clyde Consultants.